FORM PTO-1390 (REV. 5-93)	U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE	ATTORNEY'S DOCKET NUMBER 10191/1775

TRANSMITTAL LETTER TO THE UNITED STATES **DESIGNATED/ELECTED OFFICE (DO/EO/US)** **CONCERNING A FILING UNDER 35 U.S.C. 371**	U.S. APPLICATION NO. (If known, see 37 CFR 1.5) **09/857113**

INTERNATIONAL APPLICATION NO. PCT/DE99/03219	INTERNATIONAL FILING DATE (06.10.99) 06 October 1999	PRIORITY DATES CLAIMED (01.12.98) 01 December 1998

TITLE OF INVENTION
METHOD AND DEVICE FOR DETERMINING A FUTURE TRAVEL-PATH AREA OF A VEHICLE

APPLICANT(S) FOR DO/EO/US
MICHI, Harald; SCHERL, Michael; LICHTENBERG, Bernd; and UHLER, Werner

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information

1. ☒ This is a **FIRST** submission of items concerning a filing under 35 U.S.C. 371.

2. ☐ This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U.S.C. 371.

3. ☒ This express request to begin national examination procedures (35 U.S.C. 371(f)) at any time rather than delay examination until the expiration of the applicable time limit set in 35 U.S.C. 371(b) and PCT Articles 22 and 39(1).

4. ☒ A proper Demand for International Preliminary Examination was made by the 19th month from the earliest claimed priority date.

5. ☒ A copy of the International Application as filed (35 U.S.C. 371(c)(2))

   a. ☐ is transmitted herewith (required only if not transmitted by the International Bureau).

   b. ☒ has been transmitted by the International Bureau.

   c. ☐ is not required, as the application was filed in the United States Receiving Office (RO/US)

6. ☒ A translation of the International Application into English (35 U.S.C. 371(c)(2)).

7. ☒ Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371(c)(3))

   a. ☐ are transmitted herewith (required only if not transmitted by the International Bureau).

   b. ☐ have been transmitted by the International Bureau.

   c. ☐ have not been made; however, the time limit for making such amendments has NOT expired.

   d. ☒ have not been made and will not be made.

8. ☐ A translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)).

9. ☒ An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4)).

10. ☐ A translation of the annexes to the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5)).

Items 11. to 16. below concern other document(s) or information included:

11. ☒ An Information Disclosure Statement under 37 CFR 1.97 and 1.98.

12. ☒ An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.

13. ☒ A **FIRST** preliminary amendment.

   ☐ A **SECOND** or **SUBSEQUENT** preliminary amendment.

14. ☒ A substitute specification and marked up specification.

15. ☐ A change of power of attorney and/or address letter.

16. ☒ Other items or information: Copies of International Search Report, Preliminary Examination Report, and Form PCT/RO/101.

EXPRESS MAIL NO. EL244502704US

U.S. APPLICATION NO, if known, see 37 CFR 11 097857113	INTERNATIONAL APPLICATION NO PCT/DE99/03219	ATTORNEY'S DOCKET NUMBER 10191/1775

17. ☒   The following fees are submitted:

	CALCULATIONS	PTO USE ONLY

Basic National Fee (37 CFR 1.492(a)(1)-(5)):

Search Report has been prepared by the EPO or JPO $860.00

International preliminary examination fee paid to USPTO (37 CFR 1.482) . . . $690.00

No international preliminary examination fee paid to USPTO (37 CFR 1.482) but international search fee paid to USPTO (37 CFR 1.445(a)(2)) $710.00

Neither international preliminary examination fee (37 CFR 1.482) nor international search fee (37 CFR 1.445(a)(2)) paid to USPTO $1,000.00
International preliminary examination fee paid to USPTO (37 CFR 1.482) and all claims satisfied provisions of PCT Article 33(2)-(4) $100.00

ENTER APPROPRIATE BASIC FEE AMOUNT =	$860	
Surcharge of $130.00 for furnishing the oath or declaration later than ☐ 20 ☐ 30 months from the earliest claimed priority date (37 CFR 1.492(e)).	$	

Claims	Number Filed	Number Extra	Rate		
Total Claims	14 - 20 =	0	X $18.00	$	
Independent Claims	2 - 3 =	0	X $80.00	$	
Multiple dependent claim(s) (if applicable)			+ $270.00	$	

TOTAL OF ABOVE CALCULATIONS =	$860	
Reduction by ½ for filing by small entity, if applicable. Verified Small Entity statement must also be filed. (Note 37 CFR 1.9, 1.27, 1.28).	$	
SUBTOTAL =	$860	
Processing fee of $130.00 for furnishing the English translation later the ☐ 20 ☐ 30 months from the earliest claimed priority date (37 CFR 1.492(f)). +	$	
TOTAL NATIONAL FEE =	$860	
Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31). $40.00 per property +	$	
TOTAL FEES ENCLOSED =	$860	

	Amount to be: refunded	$
	charged	$

a. ☐   A check in the amount of $_____ to cover the above fees is enclosed.

b. ☒   Please charge my Deposit Account No. __11-0600__ in the amount of **$860.00** to cover the above fees. A duplicate copy of this sheet is enclosed.

c. ☒   The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment to Deposit Account No. __11-0600__ . A duplicate copy of this sheet is enclosed.

NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137(a) or (b)) must be filed and granted to restore the application to pending status.

SEND ALL CORRESPONDENCE TO:

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New York, New York 10004

26646
PATENT TRADEMARK OFFICE

CUSTOMER NO. 26646

SIGNATURE

Richard L. Mayer, Reg. No. 22,490
NAME

5/31/01
DATE

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Inventor(s)   :   MICHI et al.

Serial No.   :   To Be Assigned

Filed   :   Herewith

For   :   METHOD AND DEVICE FOR DETERMINING A
                          FUTURE TRAVEL-PATH AREA OF A VEHICLE

Examiner   :   To Be Assigned

Art Unit   :   To Be Assigned

Assistant Commissioner for Patents
Washington, D.C. 20231

PRELIMINARY AMENDMENT

SIR:

Kindly amend the above-identified application before examination, as set forth below.

IN THE TITLE:

Please replace the title with the following:

--METHOD AND DEVICE FOR DETERMINING A FUTURE TRAVEL-PATH AREA OF A VEHICLE--.

IN THE SPECIFICATION:

Please amend the specification, including abstract, pursuant to the attached substitute specification. Also attached is a marked up copy of the specification, indicating deleted and added sections. No new matter has been added.

IN THE CLAIMS:

Please cancel claims 1-14 in the underlying PCT application, without prejudice.

Please add the following new claims:

15. (New) A method for determining a future travel-path area of a first vehicle, the first vehicle equipped with a distance sensor, comprising the steps of:

determining a relative position of at least one second vehicle traveling ahead of the first vehicle, the first vehicle determining the relative position of the at least one second vehicle at predetermined timepoints using the distance sensor;

storing the determined relative position of the at least one second vehicle in a storage device, the determined relative position constituting a course path of the at least one second vehicle traveling ahead;

determining the future travel-path area of the first vehicle at least as a function of the course path of the at least one second vehicle traveling ahead; and

projecting the course path of the at least one second vehicle traveling ahead in direction of a position of the first vehicle.

16. (New) The method according to claim 15, wherein the step of projecting the course path of the at least one second vehicle includes projecting the course path of the at least one second vehicle to a position in which the first vehicle is located occurs up to the position of the first vehicle.

17. (New) The method according to claim 15, further comprising the step of:

determining at least one of a transverse offset and a curvature between the projected course path of the at least one second vehicle traveling ahead and a current course path of the first vehicle.

18. (New) The method according to claim 17, further comprising the step of:

determining the future travel-path area of the first vehicle using at least one of a transverse offset and a curvature of the current course path of the first vehicle in relation to the projected course path of the at least one second vehicle traveling ahead.

19. (New) The method according to claim 18, wherein the determining of the future travel-path area is based on a plurality of projected course paths of the at least one second vehicle traveling ahead, and further comprising:

filtering out a lane change of one of the at least one second vehicle traveling ahead using one of a comparison, a correlation, and an average of the plurality of projected course paths of all of the at least one second vehicle traveling ahead.

20. (New) The method according to claim 15, further comprising:

comparing the course path of the at least one second vehicle traveling ahead stored with at least one coordinate of the current course path of the first vehicle at at least one of selected timepoints and freely selectable timepoints.

21. (New) The method according to claim 15, wherein the step of projecting the course path of the at least one second vehicle traveling ahead is accomplished using at least one of statistical analyses and mathematical interpolation procedures on the determined relative position stored.

22. (New) The method according to claim 15, further comprising:

evaluating the projected course path of the at least one second vehicle traveling ahead using at least one performance criterion, wherein the at least one performance criterion contains a statistical component, a nonpredictable component and a predictable component.

23. (New) The method according to claim 22, further comprising:

when the at least one performance criterion of the projected course path of the at least one second vehicle traveling ahead is less than a predetermined threshold performance value, then at least one of: (i) deleting the projected course path of the at least one second vehicle traveling ahead from the storage device and (ii) not considering the projected course path of the at least one second vehicle traveling ahead in the determining of the future travel-path area of the first vehicle.

24. (New) The method according to claim 15, wherein the storage device is configured as a ring storage device.

25. (New) The method according to claim 15, further comprising:

when the storage device is full, determining whether to delete at least one of the course path stored and any new course paths, in accordance with a performance criterion based on at least one predictable component.

26. (New) The method according to claim 15, further comprising:

limiting the future travel-path area based on at least one of a position of detected stationary objects and a position of detected oncoming vehicles.

27. (New) The method according to claim 15, further comprising:

determining at least one further future travel-path area of the first vehicle based on at least one of a steering angle, a steering wheel angle, a yaw rate, a difference of wheel speed, a transverse acceleration of the first vehicle, a stationary object detected by the distance sensor of the first vehicle, and an oncoming vehicle detected by the distance sensor of the first vehicle; and

determining a verified future travel-path area based on the future travel-path area and the at least one further future travel-path area.

28. (New) A device for determining a future travel-path area of a first vehicle, the first vehicle having a current course path, comprising:

a distance sensor associated with the first vehicle to determine at predetermined time points at least a relative position of at least one vehicle traveling ahead in relation to the first vehicle;

at least one storage device configured to store the relative position determined;

an arrangement configured to determine a travel-path of the at least one vehicle traveling ahead from the at least the relative position stored in the storage device;

an arrangement configured to determine the future travel-path area of the first vehicle at least based on the travel-path of the at least one vehicle traveling ahead; and

an arrangement configured to project the travel-path of the at least one vehicle traveling ahead in direction of the current course path of the first vehicle.

REMARKS

This Preliminary Amendment cancels, without prejudice, claims 1-14 in the underlying PCT Application No. PCT/DE99/03219, and adds new claims 15-28. The new claims conform the claims to U.S. Patent and Trademark Office rules and do not add new matter to the application.

The amendments to the specification and abstract reflected in the substitute specification are to conform the specification and abstract to U.S. Patent and Trademark Office rules, and do not introduce new matter into the application.

The underlying PCT Application No. PCT/DE99/03219 includes an International Search Report and a revised International Search Report, copies of which is included. The Search Reports includes a list of documents that were considered by the Examiner in the underlying PCT application.
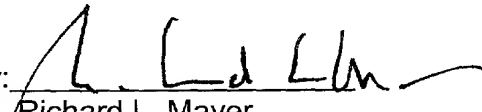
The underlying PCT Application No. PCT/DE99/03219 also includes an International Preliminary Examination Report, issued September 1, 2000. A translation of the International Preliminary Examination Report is included herewith.

It is respectfully submitted that the present invention is new, non-obvious, and useful. Prompt consideration and allowance of the claims are respectfully requested.

Respectfully Submitted,

KENYON & KENYON

Dated: 5/31/01   By: _____
                                      Richard L. Mayer
                                      Reg. No. 22,490

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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Inventor(s)	:	MICHI et al.
Serial No.	:	To Be Assigned
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Assistant Commissioner for Patents
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PRELIMINARY AMENDMENT

SIR:

Kindly amend the above-identified application before examination, as set forth below.

IN THE TITLE:

Please replace the title with the following:

--METHOD AND DEVICE FOR DETERMINING A FUTURE TRAVEL-PATH AREA OF A VEHICLE--.

IN THE SPECIFICATION:

Please amend the specification, including abstract, pursuant to the attached substitute specification. Also attached is a marked up copy of the specification, indicating deleted and added sections. No new matter has been added.

[10191/1775]

METHOD AND DEVICE FOR DETERMINING A FUTURE TRAVEL-PATH AREA OF A VEHICLE

Field of the Invention

The present invention relates to a method [as well as] and a device for determining a future travel-path area of

5   a motor vehicle. It can be applied, for example, in [the] an adaptive speed or distance control of a vehicle, in an adaptive headlight leveling adjustment, or simply in detecting critical situations. The [presupposition is that the] vehicle is furnished with at least one sensor,

10   which can detect, [and] or at least determine the position of, vehicles traveling ahead and stationary objects in the forward field of the vehicle. Sensors of this type can be configured, for example, as radar, laser, or video sensors. The present invention [is] can

15   be used [advantageously] in connection with an adaptive speed or distance control system of a vehicle[, because a sensor of this type is already present in this application].

20   ## Background Information

In past years, numerous publications have appeared, which deal with an automatic control system for the speed of a motor vehicle while taking into consideration the

25   distance with respect to vehicles traveling ahead. Systems of this type are frequently termed Adaptive Cruise Control (ACC) or, [in German,] adaptive or dynamic speed regulators. One fundamental problem in systems of this type, in view of contemporary traffic patterns, is

30   an automatic decision as to which vehicle of a plurality of vehicles traveling ahead is relevant, or most

**MARKED UP VERSION OF
SUBSTITUTE SPECIFICATION**

relevant, for the speed or distance control system. This decision is particularly [difficult in the event that] challenging when the road on which the controlled vehicle is moving is multi-lane and curvy. In this case, a distance sensor, which is used, inter alia, for detecting vehicles traveling ahead, usually also detects vehicles that are located on neighboring lanes and that therefore have only minor relevance for a distance control system.

Therefore, in an ACC system, there exists a need to determine a future course path, or a future travel-path area, of the controlled vehicle, in order, once this area is known, to determine the [specifically] most relevant vehicles traveling ahead or, conversely, to determine the obstacle that at an instantaneous time point is the most dangerous. Both variables, as well as the course path and the travel-path area, are fundamentally oriented on the direction of the road, but in the optimal case they also take into account, if appropriate, any lane changing or turning behavior carried out by the controlled vehicle. In this context, the concept "future travel-path area" is distinguished in what follows from the concept "future travel-path" in that the former contains the entire spatial area in which the controlled vehicle will probably move. This means that it also takes into account in each case the width required by the motor vehicle.

[Currently known] Conventional solutions to the aforementioned [formulation of the] problem are described, for example, in the publication "Adaptive Cruise Control -- System Aspects and Development Trends" by Winner, Witte, et al., published as SAE Technical Papers Series No. 961010 at the SAE of February 26-29, 1996. In that publication, the simplest way to predict a future course of a controlled vehicle is to assume movement in a straight line. However, [it is obvious

that] this type of prediction does not function in the case of curves or lane changes. A more complex case, which nevertheless delivers sufficient results for wide areas, is to assume a course having a constant curvature.

5 The latter is determined, for example, on the basis of a difference of wheel speeds, a steering or steering wheel angle, transverse accelerations, and/or yaw rates. Corresponding methods [are known from] can be found in the field of driving dynamic control systems. [One

10 disadvantage in] In this method [is that], the future course path or travel-path area is only estimated[,] in each case on the basis of the present course. Therefore, here too, errors arise in response to every change of course, for example, in driving into or out of curves. A

15 further possibility for predicting a course path, which is also mentioned in the cited publications, is the application of navigation systems. However, the limits of this method depend on how up-to-date and precise the available maps are and on the capacity of the system to

20 determine[,] in each case[,] the current position of the vehicle. The prediction [is particularly] may be unreliable in construction zones or on new roads. As a further possibility, [mention is made] in the above-cited publication [of], a prediction of the road course or the

25 lane based on radar data is mentioned. Stationary objects are used such as reflectors or crash barriers, which are detected by a signal processor, in order to reconstruct the road borders. However, according to the publication, little is known regarding the quality and reliability of

30 this method.

In U.S. Patent No. 4,786,164, a system and a method are described for detecting the distance between two vehicles which are moving in the same traffic lane. In this

35 context, the lane in which each of the two vehicles is moving is determined on the basis of a comparison of

angles at which reflectors that are placed on both sides
of the road are detected. However, the method described
here can only be used if suitable reflectors are actually
present on both sides of the road, and is therefore

5   dependent on infrastructure conditions.

In German Patent Application No. 196 14 061 A1, a system
is described for controlling the distance to a vehicle
traveling ahead on the basis of an adjustable probability

10   distribution. This [described] system has a curvature
determination device, in which the curvature of a road is
determined on the basis of a steering angle and a vehicle
speed. To improve the reliability, according to a first
modification, the steering angle is determined on the

15   basis of the motion of a specified stationary object. For
this purpose, the locations of a stationary object
relative to a system vehicle in motion are monitored at
uniform time intervals. The locations are then defined as
a circular arc to calculate the curvature of the road on

20   which the system vehicle is traveling. According to a
second modification, a sharp curve of the road can also
be detected on the basis of a stationary object.
According to a fourth modification, the calculated
curvature can be increased or reduced if a turning signal

25   indicates the right or left direction. According to a
tenth modification, it is possible, on the basis of a
navigation system, for example, a GPS system, to
determine whether a curve is present in a forward
direction of the system vehicle.

30
[However, not one of the methods presented in this
document removes the disadvantages already cited in
detail.

35   From German Patent 41 33 882 A1, a method is known]
German Patent No. 41 33 882 describes a method for

independently following a vehicle in the lane of a
[quite] specific vehicle traveling ahead. For this
purpose, using an electronic camera, the significant rear
area of a leading vehicle is monitored and the sideways
5   misalignment with respect to it is approximately
determined. The goal [is] appears to be to obtain control
signals for steering the vehicle carrying the camera.

[From] German Patent No. 43 41 689 [A1,] describes a
10   system [is known] for detecting a vehicle traveling
ahead. The point of departure is a center line, which
represents the extension of the vehicle axis. Around this
line, areas of varying probabilities are defined, which
are used to recognize a detected target as being located
15   in the lane or as being irrelevant. The curvature of the
road ahead is calculated on the basis of the current
steering angle and of the current speed. A displacement
is determined as a function of this predicted curvature,
at the distance at which another vehicle has been
20   detected, and the previously determined probability
distribution is shifted by this value.

[From the as yet not pre-published German patent
application 197 22 947.6-32,] German Patent Application
25   No. 197 22 947 describes a method and a device [are
known] for determining a future travel-path area of a
vehicle. There, on the basis of the detected positions of
the vehicles traveling ahead, the course paths of the
latter are observed and in each case the transverse
30   offset is determined with respect to the first vehicle's
own position. This occurs in each case at the [time]
point in time at which the first vehicle has passed the
point at which a first position of the corresponding
vehicle traveling ahead had been stored in memory. Based
35   on the knowledge of this transverse offset and of the
stored course paths of the vehicles traveling ahead, a

future travel-path area of the first vehicle can be
determined.

5   [The disadvantage of the previous] These methods and
devices appear to describe approaches to determining the
future travel-path area of a first vehicle [can be seen
in the fact that] using the earliest possible time point
for determining a travel-path area [is] as the time point
at which a point is passed at which a position of a
10   vehicle traveling ahead has been detected.

[Objective, Solution, and Advantages] Summary of the
Invention

15   The [objective of the] present invention[, accordingly,
is to indicate] provides a method and a device[, based
thereon, using which] for reliably determining a future
travel-path area of a first vehicle [can be reliably
determined. This]. According to the present invention,
20   this travel-path area [should be] is able to be
determined reliably and in a timely fashion, especially
when vehicles traveling ahead have been detected for the
first time.

25   According to the present invention, [this objective is
achieved as a result of the fact that] the future
travel-path area of the first vehicle is determined at
least on the basis of a course path of a vehicle
traveling ahead that is projected onto the position of
30   the first vehicle. This means that the detected course
path of the vehicle traveling ahead is projected into an
area in front of the first vehicle, in which no measured
positions of the vehicle traveling ahead are present.

35   [The advantage of the method according] According to the
present invention [and of the device according to the

present invention can be seen in the fact that it is already possible to determine], the future travel-path area of the first vehicle before a position is reached at which a vehicle traveling ahead has been detected[. As a result of this invention, it is possible,] <u>can be determined.</u>

<u>According to an embodiment of the present invention,</u> in accordance with the speed of the first vehicle and the range of the distance sensor, <u>it is possible</u> to gain up to two seconds in comparison with previous methods and devices, in which it is already possible to determine the future travel-path area of the first vehicle. This can contribute to reducing the pressure on the driver of the first vehicle and to increasing general driving safety.

The course path of the vehicle traveling ahead can [advantageously] be projected up until the position at which the first vehicle is located. This allows the system the maximum exploitation of the stored data for determining the future travel-path area of the first vehicle.

According to [one preferred] <u>an</u> embodiment of the present invention, [for this purpose,] a transverse offset and/or a curvature is determined between the projected course path of the vehicle traveling ahead and the current course path of the first vehicle. Using the transverse offset and/or the curvature of the course path of the first vehicle with respect to the projected course path of the vehicle traveling ahead, a future travel-path area of the first vehicle is determined. This embodiment offers the advantage that, for determining the future travel-path area of the first vehicle, it is also possible to use a projected course path of a vehicle traveling ahead which is not moving in the same traffic

lane as the first vehicle.

[According to one advantageous refinement] In a further
embodiment of the present invention, the future
travel-path area is determined on the basis of the
projected course paths of a plurality of vehicles
traveling ahead. In this context, a lane change of a
single vehicle traveling ahead is filtered out using
comparison, correlation, or an average of the projected
course paths of all vehicles traveling ahead. This
refinement, especially given the presence of many other
traffic participants, leads to improved reliability of
the method [according to the present invention and of
the] and device according to the present invention.
Therefore, all projected course paths of vehicles
traveling ahead can be used for determining the
travel-path area of the first vehicle, which results in
improving the reliability of the determined travel-path
area.

[Furthermore, it is advantageous,] Further embodiments of
the present invention provide at selected and/or freely
selectable time points[, to compare] a comparison of the
stored course paths of the vehicles traveling ahead with
the current coordinate system of the first vehicle. [This
has the advantage that the] The storage device can be
exploited [very well] for recording the projected course
paths of vehicles traveling ahead[,] because a detected
position of a vehicle traveling ahead, calculated with
respect to the current coordinate system of the first
vehicle, therefore represents a position relative to the
first vehicle[, and the]. The data to be stored can be
composed of, for example, only one distance and angle
specification.

The course path of the vehicle traveling ahead [is

advantageously] _can be_ projected using statistical
analyses and/or mathematical interpolation methods on the
stored relative positional data. This analytic approach,
and this interpolation method, make possible a very

5   precise determination of the course path to be projected.

[It is particularly advantageous to] _Further embodiments_
of the present invention evaluate the projected course
paths of the vehicles traveling ahead using at least one

10   performance index[,] which contains both statistical as
well as non-predictable and predictable components.
Therefore, it is [advantageously] possible to delete from
the storage device a projected course path of a vehicle
traveling ahead having a performance index that lies

15   beneath a predetermined threshold value, and/or not to
consider it for determining the future travel-path area
of the first vehicle. In this manner, [on the one hand,]
exploitation of the storage device is improved because
data which are less well-suited for determining the

20   future travel-path area of the first vehicle are deleted
from the storage device. [On the other hand, it is
therefore] _It is_ possible not to use less suitable data
in determining the travel-path area, which leads to a
more precise determination.

25

According to [one refinement] _a further embodiment of the_
present invention, the storage device is organized as a
ring storage device. [This refinement has the advantage
that] _The_ memory management is simplified, and

30   [therefore] determining the future course path of the
first vehicle is accelerated. Especially in this type of
storage organization, no shifting of data within the
storage device is necessary. [In plain language] _That is_,
the oldest stored data value for a course path of a

35   vehicle traveling ahead is replaced by the currently
detected value, and only a corresponding reference to the

storage location is changed.

[It is furthermore advantageous that] <u>According to a further embodiment of the present invention,</u> when the storage device is full, for storing at least one new course path of a further vehicle traveling ahead, in accordance with a further performance index which rests only on predictable components, the decision is made as to whether at least one of the previously stored course paths and/or the at least one new course path should be deleted. [This means that] <u>That is,</u> when the storage device is full, it is determined[,] using a performance index[,] whether a previously stored course path should be deleted[,] or whether the newly detected data have a worse index than all of the course paths stored in the storage device[,] and that therefore the newly stored data should be discarded.

According to [one advantageous refinement] <u>a further embodiment</u> of the present invention, the future travel-path area is limited on the basis of the positions of detected, stationary objects or on the basis of positions of detected, oncoming vehicles. This [refinement has the advantage that it is possible to sensibly limit] <u>allows for sensibly limiting</u> the determination of the future travel-path area of the first vehicle[,] which significantly increases the precision of the determined travel-path area. Furthermore, in this manner, further independent data <u>can</u> contribute to determining the future travel-path area.

According to [one particularly preferred] <u>a further</u> embodiment of the present invention, in addition to the first future travel-path area, determined in accordance with present invention, at least one further future travel-path area is determined on the basis of a steering

angle, a steering wheel angle, a yaw rate, a difference
of wheel speeds, or a transverse acceleration of the
controlled vehicle, or on the basis of stationary objects
or of oncoming vehicles which are detected by the
distance sensor of the first vehicle. On the basis of the
first and the at least one further determined future
travel-path area, a verified future travel-path area [is]
can then be determined. [In plain language, this means
that a] A future travel-path area of the controlled
vehicle [is] can be determined on the basis of different
methods that are independent of each other. By combining
these individually determined future travel-path areas,
errors individually arising in the [methods]
methods/devices can be corrected, so that the verified
future travel-path area contains an optimal prediction of
the actual travel-path area.

[One particular advantage of the method according to]
Certain embodiments of the present invention [and of the
device according to the present invention is] provide
that the future travel-path area is determined on the
basis of measuring data which actually lie in the forward
field of the controlled vehicle, and that these data are
projected in the direction of the first vehicle's own
position. In place of an estimation based on
extrapolating an instantaneous situation, the situation
actually existing in the forward field of the vehicle is
evaluated. In this manner, it is especially possible to
detect in a timely fashion the beginning or end of a
curve. As a result, the error rate is significantly
reduced compared with previously known methods. [A
further advantage is that the method] Further, the
present invention is independent of particular
infrastructure conditions, such as specially provided
reflectors on the road edge. However, if appropriate
reflectors are present, they can be taken into account

accordingly. Furthermore, the [method] <u>present invention</u> can be realized without special expense in a vehicle which is equipped with an adaptive speed regulating system, in particular without requiring an additional image pick-up and image valuation unit.

[In plain language, the] <u>The</u> movement of one or a plurality of vehicles traveling ahead is observed for determining the future course path or travel-path area of the first vehicle. In this context, as long as a detected position of a vehicle traveling ahead is not reached by the first vehicle, the detected course path of the vehicle traveling ahead is projected in the direction of the first vehicle's own position. Therefore, determining the travel-path area for the first vehicle is possible even before a position has been reached at which a vehicle traveling ahead has been detected.

<u>[Description of Exemplary Embodiments] Brief Description of the Drawings</u>

[Below, exemplary embodiments of the present invention are discussed on the basis of a drawing. The following are the contents.

Figure 1 depicts a basic representation of a device]
<u>Figure 1</u> <u>shows an embodiment</u> according to the present invention [,]<u>;</u>
[Figure 2 and Figure 3 depict two block diagrams, as an explanation of the method] <u>Figure 2</u> <u>shows a block diagram of an embodiment</u> according to the present invention [,]<u>;</u>
[Figure 4 depicts] <u>Figure 3</u> <u>shows a block diagram of an embodiment according to the present invention;</u>

Figure 4 shows a flowchart according to related art;

Figure 5 shows a flowchart according to the [aforementioned] related art[,];

Figure [5 depicts a further] 6 shows a flowchart according to the [aforementioned related art,] related art; and

[Figure 6 depicts a further flowchart according to the aforementioned related art, for a detailed explanation of the method, and

Figure 7 depicts a block diagram, as an explanation of the method] Figure 7 shows a block diagram of an embodiment according to the present invention.

Detailed Description

Figure 1 [depicts] shows a device for carrying out the method according to the present invention. A distance sensor 10, for example, a radar or a laser sensor, is connected to an evaluation and control unit 11. Evaluation and control unit 11 receives numerous further signals, of which, by way of example, an input 13 for the vehicle's own speed, an input 14 for a steering angle, and an input 15 for a yaw rate are depicted here. Furthermore, evaluation and control unit 11 is connected to one or a plurality of actuators 12. The entire device is installed in a first vehicle. Using distance sensor 10, in accordance with [the known] conventional methods, vehicles traveling ahead, oncoming vehicles, as well as stationary objects on, and on both sides of, the roadway are detected. Corresponding measuring data are pre-processed and are supplied to evaluation and control unit 11. The latter, in accordance with the method

described below, determines at least one future travel-path area of the first vehicle. In the context of an adaptive speed regulation, evaluation and control unit 11, via actuator or actuators 12, controls or regulates the speed of the vehicle. Alternatively, or as a supplement, the unit, via actuators 12, controls, for example, the headlight range or the light cone of the headlights of the vehicle, or it generates a warning signal for a critical situation.

Figure 2 [depicts] shows a two-lane road 20, on which two vehicles 21 and 22 are moving in the same direction. Reference numeral 21 designates the vehicle which has the device according to the present invention. Extending from the front of vehicle 21, an angular area 24 is sketched, which symbolizes the detection range of distance sensor 10. A dot-dash line 26 depicts the future course path of vehicle 21. Two solid lines 27 designate the future travel-path area of vehicle 21. This future travel-path area results from future course path 26 of vehicle 21, enlarged by the vehicle width and any additional expansions. A distance 23 indicates a lateral transverse offset q between vehicles 21 and 22. Reference numeral 25 designates a stationary object, for example, a tree at the road edge.

Figure 3 also [depicts] shows a two-lane road 30, on which three vehicles 31, 32, and 33, are represented at two different time points t_0 and t_1. The positions of the vehicles at time point t_0 are represented in dotted lines and are designated as 31a, 32a, and 33a. The positions of the vehicles at time point t_1 are designated as 31b, 32b, and 33b. Two distances 34 and 35 designate in each case a transverse offset q_1 and q_2 between vehicles 31 and 32 and between vehicles 31 and 33 respectively.

Figure 4 depicts a flowchart in accordance with the [aforementioned] related art. In step 41, using distance sensor 10, vehicles traveling ahead F_{v1} are detected. In this context, according to Figure 2 and Figure 3, vehicles 22 [as well as]$_L$ 32$_L$ and 33$_L$ are detected. In step 42, a position P_{vi} of each individual vehicle traveling ahead is determined. Depending on the specific configuration, this step can be carried out either by an evaluation circuit within distance sensor 10 or by evaluation and control unit 11. Determined positions P_{vi} of vehicles traveling ahead F_{v1} contain a distance d_i and an angle α_1. In step 43, a transverse offset q_1 is determined, which in Figures 2 and 3 is indicated by the distances 23, 34, and 35. In purely mathematical terms, transverse offset q_1 yields

$$q_i = d_1 * \sin\alpha_1.$$

However, because the curvature of road 20, and 30, and an additional transverse offset of vehicles F_{v1}, resulting therefrom, are not taken into account in this connection, specific transverse offset q_i is determined on the basis of position P of vehicle 31 at time point t_1 and of position P_{v1} of vehicles traveling ahead 32, 33 at time point t_0. In other words, transverse offset q_1 in this context is only determined if first vehicle 31 is located at or near the position which the specific vehicle traveling ahead occupied at one or more measuring time points previously.

In step 44, future travel-path area KB of controlled vehicle 21, 31 is determined on the basis of an assumed width b of the first vehicle, [on the basis of] course path KV_i of vehicles traveling ahead F_{vi}, [on the basis of] the latter's specific transverse offset q_i, and, if appropriate, [on the basis of] previously determined

course paths. In this context, the assumption is made that the first vehicle will continue to move as the vehicle traveling ahead or vehicles. When an intended or commencing lane change of the first vehicle is detected,

5   for example, as a function of a blinker signal, the determined probable travel-path area is expanded in the corresponding direction. This distinguishes determined future travel-path area KB from a pure prediction of the road course. In step 47, the determination of future

10   travel-path area KB of the first vehicle is carried out in an iterative manner, i.e., it is followed by a new determination cycle. In step 45, the determined future travel-path area is limited on the basis of stationary objects 25, and, if present, on the basis of detected

15   oncoming vehicles F_G, which are not shown in Figures 2 and 3.

Subsequent step 46 relates to the application in the context of an adaptive speed and distance control system.

20   Here, a vehicle traveling ahead is selected as the control target for the distance control system. In this context, only those vehicles traveling ahead are taken into account which are located within determined future travel-path area KB. If a plurality of vehicles traveling

25   ahead are located in this area, then a selection is carried out concerning which of the vehicles traveling ahead requires the smallest desired acceleration, or the greatest desired deceleration, in the controlled vehicle. However, the selection, alternatively or as a supplement,

30   can also be made as a function of other criteria. For example, the selection can be carried out in accordance with which of the vehicles traveling ahead has the least distance from the first, controlled vehicle. Reference numeral 48 designates the iterative repetition of the

35   method.

Figure 5 depicts a further flowchart in accordance with the [above-mentioned] related art. Steps 51 through 54, in this context, correspond to steps 41 through 44 according to the related art in Figure 4. According to this second example [from the related art], in step 55, a determination is made of the verified, future travel-path area KBver. For this purpose, in step 56, further measuring data are used, especially future travel-path area KB_2, determined elsewhere. This future travel-path area KB_2, which is determined elsewhere, can be determined, for example, on the basis of the methods known in the related art, using a yaw rate or a transverse acceleration. By linking a plurality of determined future travel-path areas that are independent of each other, the error rate present in a given system is further minimized. In the simplest case, linking two determined future travel-path areas KB and KB_2 is carried out as a result of the fact that first determined travel-path area KB is used as long as an preestablished minimum number of vehicles traveling ahead is detected. If fewer vehicles traveling ahead [are detected] than this preestablished number are detected, then future travel-path area KB_2 is used. Alternatively, the data of both determined travel-path areas KB and KB_2 can also be correlated with each other, to obtain verified travel-path area KBver. In step 58, determining a future verified travel-path area also takes place in an iterative manner. Step 57 corresponds to step 46 from Figure 4 and also contains a target selection of one vehicle traveling ahead in the context of an adaptive speed and distance regulation.

Figure 6 depicts a further flowchart according to the [above-mentioned] related art for a more detailed representation of the method steps for determining future travel-path area KB in steps 44 and 54 of Figures 4 and

5. Accordingly, steps 61 through 63 can be inserted in place of steps 44 and 54 in Figures 4 and 5. In step 61, points of reference S_i are determined, in that positions P_{v_1} of detected vehicles traveling ahead F_{v_1} are set off against the relevant determined transverse offsets q_i. In the ideal case, all determined points of reference S_i will lie on one curve, which corresponds to future course path KV of the first vehicle. In step 62, this course path KV is determined, in that a function is determined, for example, in the form of a polynomial, which at least approximately, to the extent possible, covers all points of reference S_i. This determined function then describes future course path KV. In step 63, future travel-path area KB is determined, in that course path KV is expanded by width b of the first vehicle. Additionally, if necessary, a further expansion E takes place as a function of the detected lane-change signals of the first vehicle.

Figure 7 depicts a schematic diagram[, as an explanation of the method according to] of an embodiment of the present invention. In this context, reference numeral 700 designates the first vehicle, which is traveling on a multilane road 701. In the further course of road 701, two vehicles traveling ahead 702 and 703 are depicted. At the edge of road 701 are also located traffic signs 704, directional posts 705, and trees, which are designated as 706. [It is clear that first] First vehicle 700 is moving on the center lane of three-lane road 701. Vehicle traveling ahead 702 is moving on the right-hand lane relative to vehicle 700, whereas vehicle traveling ahead 703 is moving on the left-hand lane relative to first vehicle 700. First vehicle 700 is equipped with a distance sensor, which detects the positions of vehicles traveling ahead. The detected positions of vehicle traveling ahead 702 are depicted as crosses and are

designated as 707. The detected positions of vehicle traveling ahead 703 are also depicted as crosses and are designated as 708. In the case of vehicle traveling ahead 702, [it is clear that] the positions of vehicle 702 have already been detected by first vehicle 700, the positions being located at least at the same level as first vehicle 700 or even on the path already traveled. Using positions 707, detected in this manner and stored in a storage unit, [it is possible to determine] a comparison curve[,] can be determined which represents course path 709 of vehicle traveling ahead 702. Based on the course path of vehicle traveling ahead 702 and of the known position of first vehicle 700, [it is easy to determine] the transverse offset 711 between first vehicle 700 and course path 709 of vehicle traveling ahead 702 can be determined. Assuming that vehicle traveling ahead 702 is the only vehicle traveling ahead, it would be possible to determine the future course path of first vehicle 700 on the basis of known course path 709 of vehicle traveling ahead 702 and of known transverse offset 711. This future course path of first vehicle 700, if only one reference vehicle 702 is forward, would move by transverse offset 711, shifted parallel to course path 709.

In the case of vehicle traveling ahead 703, no detected positions 708 are yet present, which are located at least at the same level as first vehicle 700. The first detected position of vehicle 703 is designated as 708.a and is situated still in front of the current position of first vehicle 700. On the basis of detected positions 708 of vehicle 703, by analogy to the procedure for vehicle 702, an offset line 710 can be determined, which represents the course path of vehicle traveling ahead 703. If course path 710 of vehicle 703 is projected, or interpolated, in the direction of first vehicle 700, the result is an extension of course path 710 by path 710.a,

which extends up to the current position of first vehicle 700. Based on this projected course path 710.a of vehicle 703, it is possible to determine a transverse offset between the current position of first vehicle 700 and

5   projected course path 710.a of vehicle 703. This transverse offset, designated as 712, with respect to vehicle 703 can therefore be determined, although first vehicle 700 has not yet reached the position of the first detection of vehicle 703, which is designated as 708.a.

10   Therefore, from the point of view of first vehicle 700, two transverse offsets 711 and 712 with respect to vehicles traveling ahead 702 and 703 are known. Furthermore, both course paths 709 and 710 of vehicles traveling ahead 702 and 703 are known. Using this known

15   data, [it is now possible to determine] a future course path of first vehicle 700 on the basis of the two vehicles traveling ahead <u>can now be determined</u>. For this purpose, appropriately taking into account transverse offsets 711 and 712, the average value of course paths

20   709 and 710 is formed. The result is a determined future course path of first vehicle 700, which is designated in Figure 7 as 713. This determined future course path 713, by analogy to the related art according to Figure 6, is enlarged by the vehicle width as well as by any

25   expansions. Course path 713 of first vehicle 700, expanded in this manner, represents the desired future travel-path area of first vehicle 700.[For reasons of simplicity, this determined future travel-path area is not depicted in Figure 7.]

30

Alternatively, in place of determining the transverse offset between first vehicle 700 and course paths 709 and 710 of vehicles traveling ahead 702 and 703, a curvature between the current course path of first vehicle 700 and

35   determined course paths 709 and 710 of vehicles traveling ahead 702 and 703 can be determined. On the basis of

these known curvatures with respect to the course paths of the vehicles traveling ahead, a determination of a future course path of first vehicle 700 is also possible.

5   The determination of the future course path of first vehicle 700 is all the more precise, the greater the number of vehicles traveling ahead detected and their course paths determined. In this case, [the possibility exists to determine] a verified future course path of

10   first vehicle 700 through comparison, correlation, or an average of the projected course paths of all vehicles traveling ahead can be determined. In this context, projected course paths of vehicles traveling ahead can be filtered out, which, e.g., turn or, as a result of rapid

15   lane change between the individual traffic lanes, do not yield any reliable course path or one that is suitable for the determination of the future travel-path area.

Analytically, the conversion of detected relative

20   positional data 707 and 708 of vehicles traveling ahead 702 and 703 is accomplished using statistical analyses and/or using mathematical interpolation procedures. The result of this method is the projected course paths of the vehicles traveling ahead, which are stored in the

25   storage device of the distance sensor of first vehicle 700. Within the storage device, which is organized preferably as a ring storage device, the stored projected course paths of the vehicles traveling ahead, at selected or freely selectable time points, are compared with the

30   current coordinate system of the first vehicle. As a result of this conversion, the projected course paths of vehicles traveling ahead, at every time point, exist in the same coordinate system as the coordinate system of first vehicle 700. In order to assume the most relevant

35   of the determined projected course paths of the vehicles traveling ahead in determining the future course path of

first vehicle 700, the projected course paths of the vehicles traveling ahead are evaluated using a performance index, which contains statistical as well as nonpredictable and predictable components. On the basis

5   of this performance index, in the case of values that lie below a predetermined threshold value, it can be decided whether a projected course path of a vehicle traveling ahead is determined as being irrelevant and therefore is deleted from the storage device, or whether, e.g., the

10   relevance of this projected course path is only conditionally present, and the course path is not to be considered for determining the future travel-path area of the first vehicle. In the event that the storage device of the distance sensor of first vehicle 700 is full and

15   detected relative positional data of further vehicles traveling ahead are present, then, in accordance with a further performance index, which in this case nevertheless only relies on predictable components, the decision is made whether the newly detected course path

20   of a vehicle traveling ahead is so relevant that a previously stored projected course path of a vehicle traveling ahead should be deleted, or whether the newly detected relative positional data should be discarded. Using this method, it [is] <u>can be</u> assured that, at every

25   time point, the most relevant of the projected course paths of the vehicles traveling ahead are present in the storage device.

In the event that, on the basis of particular conditions

30   or circumstances, the determined future travel-path area of first vehicle 700 extends beyond the area of road 701, then the future travel-path area is limited on the basis of stationary objects. This can be, e.g., as [depicted] <u>shown</u> in Figure 7, traffic signs 704, guide posts 705, or

35   trees and/or bushes 706. Also possible is a limitation of the determined future travel-path area on the basis of

the positions of detected oncoming vehicles. [This latter possibility is not depicted in Figure 7.]

If a further future travel-path area of first vehicle 700 is determined, then verification of the future travel-path area of first vehicle 700 is possible. This further future travel-path area of first vehicle 700 can be determined, for example, on the basis of a steering angle, a steering wheel angle, a yaw rate, a difference between wheel speeds, or a transverse acceleration of the first vehicle, or on the basis of stationary objects or oncoming vehicles. In this manner, the future course path, or the future travel-path area, of first vehicle 700 is verified using different methods which are fully independent of each other. [This makes possible the best possible determination of the future travel-path area of first vehicle 700.]

Abstract

A method and a device are described for determining a
future travel-path area of a first vehicle[(700)], which
5   is furnished with a distance sensor. In this context,
using the distance sensor at preestablished or selectable
time points, at least relative positions [(707, 708)] are
determined of at least one vehicle traveling ahead [(702,
703)] with respect to the first vehicle[(700)]. At least
10   these determined relative positions [(707, 708)] are
stored in at least one storage device. These relative
positions[(707, 708)], stored in the storage device,
constitute in each case a course path [(709, 710)] of the
corresponding vehicle traveling ahead[(702, 703)]. The
15   future travel-path area of the first vehicle [(700)] is
determined at least on the basis of the course path
[(709, 710)] of the vehicle traveling ahead[(702, 703)].
The course path [(709, 710)] of the vehicle traveling
ahead [(702, 703)] is projected in the direction of the
20   position of the first vehicle[(700)].

[
(Figure 7)]

**MARKED UP VERSION OF
SUBSTITUTE SPECIFICATION**

[10191/1775]

METHOD AND DEVICE FOR DETERMINING A FUTURE TRAVEL-PATH AREA OF A VEHICLE

Field of the Invention

The present invention relates to a method and a device
for determining a future travel-path area of a motor

5   vehicle. It can be applied, for example, in an adaptive
speed or distance control of a vehicle, in an adaptive
headlight leveling adjustment, or simply in detecting
critical situations. The vehicle is furnished with at
least one sensor, which can detect, or at least determine

10   the position of, vehicles traveling ahead and stationary
objects in the forward field of the vehicle. Sensors of
this type can be configured, for example, as radar,
laser, or video sensors. The present invention can be
used in connection with an adaptive speed or distance

15   control system of a vehicle.

Background Information

In past years, numerous publications have appeared, which
20   deal with an automatic control system for the speed of a
motor vehicle while taking into consideration the
distance with respect to vehicles traveling ahead.
Systems of this type are frequently termed Adaptive
Cruise Control (ACC) or, adaptive or dynamic speed
25   regulators. One fundamental problem in systems of this
type, in view of contemporary traffic patterns, is an
automatic decision as to which vehicle of a plurality of
vehicles traveling ahead is relevant, or most relevant,
for the speed or distance control system. This decision
30   is particularly challenging when the road on which the
controlled vehicle is moving is multi-lane and curvy. In

SUBSTITUTE SPECIFICATION

this case, a distance sensor, which is used, inter alia, for detecting vehicles traveling ahead, usually also detects vehicles that are located on neighboring lanes and that therefore have only minor relevance for a distance control system.

Therefore, in an ACC system, there exists a need to determine a future course path, or a future travel-path area, of the controlled vehicle, in order, once this area is known, to determine the most relevant vehicles traveling ahead or, conversely, to determine the obstacle that at an instantaneous time point is the most dangerous. Both variables, as well as the course path and the travel-path area, are fundamentally oriented on the direction of the road, but in the optimal case they also take into account, if appropriate, any lane changing or turning behavior carried out by the controlled vehicle. In this context, the concept "future travel-path area" is distinguished in what follows from the concept "future travel-path" in that the former contains the entire spatial area in which the controlled vehicle will probably move. This means that it also takes into account in each case the width required by the motor vehicle.

Conventional solutions to the aforementioned problem are described, for example, in the publication "Adaptive Cruise Control -- System Aspects and Development Trends" by Winner, Witte, et al., published as SAE Technical Papers Series No. 961010 at the SAE of February 26-29, 1996. In that publication, the simplest way to predict a future course of a controlled vehicle is to assume movement in a straight line. However, this type of prediction does not function in the case of curves or lane changes. A more complex case, which nevertheless delivers sufficient results for wide areas, is to assume a course having a constant curvature. The latter is determined, for example, on the basis of a difference of

wheel speeds, a steering or steering wheel angle, transverse accelerations, and/or yaw rates. Corresponding methods can be found in the field of driving dynamic control systems. In this method, the future course path or travel-path area is only estimated in each case on the basis of the present course. Therefore, here too, errors arise in response to every change of course, for example, in driving into or out of curves. A further possibility for predicting a course path, which is also mentioned in the cited publications, is the application of navigation systems. However, the limits of this method depend on how up-to-date and precise the available maps are and on the capacity of the system to determine in each case the current position of the vehicle. The prediction may be unreliable in construction zones or on new roads. As a further possibility, in the above-cited publication, a prediction of the road course or the lane based on radar data is mentioned. Stationary objects are used such as reflectors or crash barriers, which are detected by a signal processor, in order to reconstruct the road borders. However, according to the publication, little is known regarding the quality and reliability of this method.

In U.S. Patent No. 4,786,164, a system and a method are described for detecting the distance between two vehicles which are moving in the same traffic lane. In this context, the lane in which each of the two vehicles is moving is determined on the basis of a comparison of angles at which reflectors that are placed on both sides of the road are detected. However, the method described here can only be used if suitable reflectors are actually present on both sides of the road, and is therefore dependent on infrastructure conditions.

In German Patent Application No. 196 14 061 A1, a system is described for controlling the distance to a vehicle

traveling ahead on the basis of an adjustable probability distribution. This system has a curvature determination device, in which the curvature of a road is determined on the basis of a steering angle and a vehicle speed. To improve the reliability, according to a first modification, the steering angle is determined on the basis of the motion of a specified stationary object. For this purpose, the locations of a stationary object relative to a system vehicle in motion are monitored at uniform time intervals. The locations are then defined as a circular arc to calculate the curvature of the road on which the system vehicle is traveling. According to a second modification, a sharp curve of the road can also be detected on the basis of a stationary object. According to a fourth modification, the calculated curvature can be increased or reduced if a turning signal indicates the right or left direction. According to a tenth modification, it is possible, on the basis of a navigation system, for example, a GPS system, to determine whether a curve is present in a forward direction of the system vehicle.

German Patent No. 41 33 882 describes a method for independently following a vehicle in the lane of a specific vehicle traveling ahead. For this purpose, using an electronic camera, the significant rear area of a leading vehicle is monitored and the sideways misalignment with respect to it is approximately determined. The goal appears to be to obtain control signals for steering the vehicle carrying the camera.

German Patent No. 43 41 689 describes a system for detecting a vehicle traveling ahead. The point of departure is a center line, which represents the extension of the vehicle axis. Around this line, areas of varying probabilities are defined, which are used to recognize a detected target as being located in the lane

or as being irrelevant. The curvature of the road ahead
is calculated on the basis of the current steering angle
and of the current speed. A displacement is determined as
a function of this predicted curvature, at the distance
5   at which another vehicle has been detected, and the
previously determined probability distribution is shifted
by this value.

German Patent Application No. 197 22 947 describes a
10   method and a device for determining a future travel-path
area of a vehicle. There, on the basis of the detected
positions of the vehicles traveling ahead, the course
paths of the latter are observed and in each case the
transverse offset is determined with respect to the first
15   vehicle's own position. This occurs in each case at the
point in time at which the first vehicle has passed the
point at which a first position of the corresponding
vehicle traveling ahead had been stored in memory. Based
on the knowledge of this transverse offset and of the
20   stored course paths of the vehicles traveling ahead, a
future travel-path area of the first vehicle can be
determined.

These methods and devices appear to describe approaches
25   to determining the future travel-path area of a first
vehicle using the earliest possible time point for
determining a travel-path area as the time point at which
a point is passed at which a position of a vehicle
traveling ahead has been detected.
30

Summary of the Invention

The present invention provides a method and a device for
reliably determining a future travel-path area of a first
35   vehicle. According to the present invention, this
travel-path area is able to be determined reliably and in
a timely fashion, especially when vehicles traveling

ahead have been detected for the first time.

According to the present invention, the future travel-path area of the first vehicle is determined at least on the basis of a course path of a vehicle traveling ahead that is projected onto the position of the first vehicle. This means that the detected course path of the vehicle traveling ahead is projected into an area in front of the first vehicle, in which no measured positions of the vehicle traveling ahead are present.

According to the present invention, the future travel-path area of the first vehicle before a position is reached at which a vehicle traveling ahead has been detected can be determined.

According to an embodiment of the present invention, in accordance with the speed of the first vehicle and the range of the distance sensor, it is possible to gain up to two seconds in comparison with previous methods and devices, in which it is already possible to determine the future travel-path area of the first vehicle. This can contribute to reducing the pressure on the driver of the first vehicle and to increasing general driving safety.

The course path of the vehicle traveling ahead can be projected up until the position at which the first vehicle is located. This allows the system the maximum exploitation of the stored data for determining the future travel-path area of the first vehicle.

According to an embodiment of the present invention, a transverse offset and/or a curvature is determined between the projected course path of the vehicle traveling ahead and the current course path of the first vehicle. Using the transverse offset and/or the curvature of the course path of the first vehicle with respect to

the projected course path of the vehicle traveling ahead, a future travel-path area of the first vehicle is determined. This embodiment offers the advantage that, for determining the future travel-path area of the first vehicle, it is also possible to use a projected course path of a vehicle traveling ahead which is not moving in the same traffic lane as the first vehicle.

In a further embodiment of the present invention, the future travel-path area is determined on the basis of the projected course paths of a plurality of vehicles traveling ahead. In this context, a lane change of a single vehicle traveling ahead is filtered out using comparison, correlation, or an average of the projected course paths of all vehicles traveling ahead. This refinement, especially given the presence of many other traffic participants, leads to improved reliability of the method and device according to the present invention. Therefore, all projected course paths of vehicles traveling ahead can be used for determining the travel-path area of the first vehicle, which results in improving the reliability of the determined travel-path area.

Further embodiments of the present invention provide at selected and/or freely selectable time points a comparison of the stored course paths of the vehicles traveling ahead with the current coordinate system of the first vehicle. The storage device can be exploited for recording the projected course paths of vehicles traveling ahead because a detected position of a vehicle traveling ahead, calculated with respect to the current coordinate system of the first vehicle, therefore represents a position relative to the first vehicle. The data to be stored can be composed of, for example, only one distance and angle specification.

The course path of the vehicle traveling ahead can be projected using statistical analyses and/or mathematical interpolation methods on the stored relative positional data. This analytic approach, and this interpolation method, make possible a very precise determination of the course path to be projected.

Further embodiments of the present invention evaluate the projected course paths of the vehicles traveling ahead using at least one performance index which contains both statistical as well as non-predictable and predictable components. Therefore, it is possible to delete from the storage device a projected course path of a vehicle traveling ahead having a performance index that lies beneath a predetermined threshold value, and/or not to consider it for determining the future travel-path area of the first vehicle. In this manner, exploitation of the storage device is improved because data which are less well-suited for determining the future travel-path area of the first vehicle are deleted from the storage device. It is possible not to use less suitable data in determining the travel-path area, which leads to a more precise determination.

According to a further embodiment of the present invention, the storage device is organized as a ring storage device. The memory management is simplified, and determining the future course path of the first vehicle is accelerated. Especially in this type of storage organization, no shifting of data within the storage device is necessary. That is, the oldest stored data value for a course path of a vehicle traveling ahead is replaced by the currently detected value, and only a corresponding reference to the storage location is changed.

According to a further embodiment of the present

invention, when the storage device is full, for storing at least one new course path of a further vehicle traveling ahead, in accordance with a further performance index which rests only on predictable components, the decision is made as to whether at least one of the previously stored course paths and/or the at least one new course path should be deleted. That is, when the storage device is full, it is determined using a performance index whether a previously stored course path should be deleted or whether the newly detected data have a worse index than all of the course paths stored in the storage device and that therefore the newly stored data should be discarded.

According to a further embodiment of the present invention, the future travel-path area is limited on the basis of the positions of detected, stationary objects or on the basis of positions of detected, oncoming vehicles. This allows for sensibly limiting the determination of the future travel-path area of the first vehicle which significantly increases the precision of the determined travel-path area. Furthermore, in this manner, further independent data can contribute to determining the future travel-path area.

According to a further embodiment of the present invention, in addition to the first future travel-path area, determined in accordance with present invention, at least one further future travel-path area is determined on the basis of a steering angle, a steering wheel angle, a yaw rate, a difference of wheel speeds, or a transverse acceleration of the controlled vehicle, or on the basis of stationary objects or of oncoming vehicles which are detected by the distance sensor of the first vehicle. On the basis of the first and the at least one further determined future travel-path area, a verified future travel-path area can then be determined. A future travel-

path area of the controlled vehicle can be determined on the basis of different methods that are independent of each other. By combining these individually determined future travel-path areas, errors individually arising in the methods/devices can be corrected, so that the verified future travel-path area contains an optimal prediction of the actual travel-path area.

Certain embodiments of the present invention provide that the future travel-path area is determined on the basis of measuring data which actually lie in the forward field of the controlled vehicle, and that these data are projected in the direction of the first vehicle's own position. In place of an estimation based on extrapolating an instantaneous situation, the situation actually existing in the forward field of the vehicle is evaluated. In this manner, it is especially possible to detect in a timely fashion the beginning or end of a curve. As a result, the error rate is significantly reduced compared with previously known methods. Further, the present invention is independent of particular infrastructure conditions, such as specially provided reflectors on the road edge. However, if appropriate reflectors are present, they can be taken into account accordingly. Furthermore, the present invention can be realized without special expense in a vehicle which is equipped with an adaptive speed regulating system, in particular without requiring an additional image pick-up and image valuation unit.

The movement of one or a plurality of vehicles traveling ahead is observed for determining the future course path or travel-path area of the first vehicle. In this context, as long as a detected position of a vehicle traveling ahead is not reached by the first vehicle, the detected course path of the vehicle traveling ahead is projected in the direction of the first vehicle's own position. Therefore, determining the travel-path area for

the first vehicle is possible even before a position has
been reached at which a vehicle traveling ahead has been
detected.

5   Brief Description of the Drawings

        Figure 1   shows an embodiment according to the present
                   invention;
        Figure 2   shows a block diagram of an embodiment
10   according to the present invention;
        Figure 3   shows a block diagram of an embodiment
                   according to the present invention;
        Figure 4   shows a flowchart according to related art;
        Figure 5   shows a flowchart according to the related art;
15   Figure 6   shows a flowchart according to the related art;
                   and
        Figure 7   shows a block diagram of an embodiment
                   according to the present invention.

20   Detailed Description

        Figure 1 shows a device for carrying out the method
        according to the present invention. A distance sensor 10,
        for example, a radar or a laser sensor, is connected to
25   an evaluation and control unit 11. Evaluation and control
        unit 11 receives numerous further signals, of which, by
        way of example, an input 13 for the vehicle's own speed,
        an input 14 for a steering angle, and an input 15 for a
        yaw rate are depicted here. Furthermore, evaluation and
30   control unit 11 is connected to one or a plurality of
        actuators 12. The entire device is installed in a first
        vehicle. Using distance sensor 10, in accordance with
        conventional methods, vehicles traveling ahead, oncoming
        vehicles, as well as stationary objects on, and on both
35   sides of, the roadway are detected. Corresponding
        measuring data are pre-processed and are supplied to
        evaluation and control unit 11. The latter, in accordance

with the method described below, determines at least one
future travel-path area of the first vehicle. In the
context of an adaptive speed regulation, evaluation and
control unit 11, via actuator or actuators 12, controls
or regulates the speed of the vehicle. Alternatively, or
as a supplement, the unit, via actuators 12, controls,
for example, the headlight range or the light cone of the
headlights of the vehicle, or it generates a warning
signal for a critical situation.

Figure 2 shows a two-lane road 20, on which two vehicles
21 and 22 are moving in the same direction. Reference
numeral 21 designates the vehicle which has the device
according to the present invention. Extending from the
front of vehicle 21, an angular area 24 is sketched,
which symbolizes the detection range of distance sensor
10. A dot-dash line 26 depicts the future course path of
vehicle 21. Two solid lines 27 designate the future
travel-path area of vehicle 21. This future travel-path
area results from future course path 26 of vehicle 21,
enlarged by the vehicle width and any additional
expansions. A distance 23 indicates a lateral transverse
offset q between vehicles 21 and 22. Reference numeral 25
designates a stationary object, for example, a tree at
the road edge.

Figure 3 also shows a two-lane road 30, on which three
vehicles 31, 32, and 33, are represented at two different
time points t_0 and t_1. The positions of the vehicles at
time point t_0 are represented in dotted lines and are
designated as 31a, 32a, and 33a. The positions of the
vehicles at time point t_1 are designated as 31b, 32b, and
33b. Two distances 34 and 35 designate in each case a
transverse offset q_1 and q_2 between vehicles 31 and 32 and
between vehicles 31 and 33 respectively.

Figure 4 depicts a flowchart in accordance with the

related art. In step 41, using distance sensor 10, vehicles traveling ahead F_{vi} are detected. In this context, according to Figure 2 and Figure 3, vehicles 22, 32, and 33, are detected. In step 42, a position P_{vi} of each individual vehicle traveling ahead is determined. Depending on the specific configuration, this step can be carried out either by an evaluation circuit within distance sensor 10 or by evaluation and control unit 11. Determined positions P_{vi} of vehicles traveling ahead F_{vi} contain a distance d_i and an angle α_i. In step 43, a transverse offset q_i is determined, which in Figures 2 and 3 is indicated by the distances 23, 34, and 35. In purely mathematical terms, transverse offset q_i yields

$$q_i = d_i * \sin\alpha_i.$$

However, because the curvature of road 20, and 30, and an additional transverse offset of vehicles F_{vi}, resulting therefrom, are not taken into account in this connection, specific transverse offset q_i is determined on the basis of position P of vehicle 31 at time point t_1 and of position P_{vi} of vehicles traveling ahead 32, 33 at time point t_0. In other words, transverse offset q_i in this context is only determined if first vehicle 31 is located at or near the position which the specific vehicle traveling ahead occupied at one or more measuring time points previously.

In step 44, future travel-path area KB of controlled vehicle 21, 31 is determined on the basis of an assumed width b of the first vehicle, course path KV_i of vehicles traveling ahead F_{vi}, the latter's specific transverse offset q_i, and, if appropriate, previously determined course paths. In this context, the assumption is made that the first vehicle will continue to move as the vehicle traveling ahead or vehicles. When an intended or commencing lane change of the first vehicle is detected,

for example, as a function of a blinker signal, the
determined probable travel-path area is expanded in the
corresponding direction. This distinguishes determined
future travel-path area KB from a pure prediction of the
road course. In step 47, the determination of future
travel-path area KB of the first vehicle is carried out
in an iterative manner, i.e., it is followed by a new
determination cycle. In step 45, the determined future
travel-path area is limited on the basis of stationary
objects 25, and, if present, on the basis of detected
oncoming vehicles F_G, which are not shown in Figures 2 and
3.

Subsequent step 46 relates to the application in the
context of an adaptive speed and distance control system.
Here, a vehicle traveling ahead is selected as the
control target for the distance control system. In this
context, only those vehicles traveling ahead are taken
into account which are located within determined future
travel-path area KB. If a plurality of vehicles traveling
ahead are located in this area, then a selection is
carried out concerning which of the vehicles traveling
ahead requires the smallest desired acceleration, or the
greatest desired deceleration, in the controlled vehicle.
However, the selection, alternatively or as a supplement,
can also be made as a function of other criteria. For
example, the selection can be carried out in accordance
with which of the vehicles traveling ahead has the least
distance from the first, controlled vehicle. Reference
numeral 48 designates the iterative repetition of the
method.

Figure 5 depicts a further flowchart in accordance with
the related art. Steps 51 through 54, in this context,
correspond to steps 41 through 44 according to the
related art in Figure 4. According to this second
example, in step 55, a determination is made of the

verified, future travel-path area KBver. For this
purpose, in step 56, further measuring data are used,
especially future travel-path area KB_2, determined
elsewhere. This future travel-path area KB_2, which is
determined elsewhere, can be determined, for example, on
the basis of the methods known in the related art, using
a yaw rate or a transverse acceleration. By linking a
plurality of determined future travel-path areas that are
independent of each other, the error rate present in a
given system is further minimized. In the simplest case,
linking two determined future travel-path areas KB and KB_2
is carried out as a result of the fact that first
determined travel-path area KB is used as long as an
preestablished minimum number of vehicles traveling ahead
is detected. If fewer vehicles traveling ahead than this
preestablished number are detected, then future travel-
path area KB_2 is used. Alternatively, the data of both
determined travel-path areas KB and KB_2 can also be
correlated with each other, to obtain verified travel-
path area KBver. In step 58, determining a future
verified travel-path area also takes place in an
iterative manner. Step 57 corresponds to step 46 from
Figure 4 and also contains a target selection of one
vehicle traveling ahead in the context of an adaptive
speed and distance regulation.

Figure 6 depicts a further flowchart according to the
related art for a more detailed representation of the
method steps for determining future travel-path area KB
in steps 44 and 54 of Figures 4 and 5. Accordingly, steps
61 through 63 can be inserted in place of steps 44 and 54
in Figures 4 and 5. In step 61, points of reference S_1 are
determined, in that positions P_{vi} of detected vehicles
traveling ahead F_{vi} are set off against the relevant
determined transverse offsets q_i. In the ideal case, all
determined points of reference S_1 will lie on one curve,
which corresponds to future course path KV of the first

vehicle. In step 62, this course path KV is determined, in that a function is determined, for example, in the form of a polynomial, which at least approximately, to the extent possible, covers all points of reference S_i.

5   This determined function then describes future course path KV. In step 63, future travel-path area KB is determined, in that course path KV is expanded by width b of the first vehicle. Additionally, if necessary, a further expansion E takes place as a function of the

10   detected lane-change signals of the first vehicle.

Figure 7 depicts a schematic diagram of an embodiment of the present invention. In this context, reference numeral 700 designates the first vehicle, which is

15   traveling on a multilane road 701. In the further course of road 701, two vehicles traveling ahead 702 and 703 are depicted. At the edge of road 701 are also located traffic signs 704, directional posts 705, and trees, which are designated as 706. First vehicle 700 is moving

20   on the center lane of three-lane road 701. Vehicle traveling ahead 702 is moving on the right-hand lane relative to vehicle 700, whereas vehicle traveling ahead 703 is moving on the left-hand lane relative to first vehicle 700. First vehicle 700 is equipped with a

25   distance sensor, which detects the positions of vehicles traveling ahead. The detected positions of vehicle traveling ahead 702 are depicted as crosses and are designated as 707. The detected positions of vehicle traveling ahead 703 are also depicted as crosses and are

30   designated as 708. In the case of vehicle traveling ahead 702, the positions of vehicle 702 have already been detected by first vehicle 700, the positions being located at least at the same level as first vehicle 700 or even on the path already traveled. Using positions

35   707, detected in this manner and stored in a storage unit, a comparison curve can be determined which represents course path 709 of vehicle traveling ahead

702. Based on the course path of vehicle traveling ahead
702 and of the known position of first vehicle 700, the
transverse offset 711 between first vehicle 700 and
course path 709 of vehicle traveling ahead 702 can be

5   determined. Assuming that vehicle traveling ahead 702 is
the only vehicle traveling ahead, it would be possible to
determine the future course path of first vehicle 700 on
the basis of known course path 709 of vehicle traveling
ahead 702 and of known transverse offset 711. This future

10   course path of first vehicle 700, if only one reference
vehicle 702 is forward, would move by transverse offset
711, shifted parallel to course path 709.

In the case of vehicle traveling ahead 703, no detected

15   positions 708 are yet present, which are located at least
at the same level as first vehicle 700. The first
detected position of vehicle 703 is designated as 708.a
and is situated still in front of the current position of
first vehicle 700. On the basis of detected positions 708

20   of vehicle 703, by analogy to the procedure for vehicle
702, an offset line 710 can be determined, which
represents the course path of vehicle traveling ahead
703. If course path 710 of vehicle 703 is projected, or
interpolated, in the direction of first vehicle 700, the

25   result is an extension of course path 710 by path 710.a,
which extends up to the current position of first vehicle
700. Based on this projected course path 710.a of vehicle
703, it is possible to determine a transverse offset
between the current position of first vehicle 700 and

30   projected course path 710.a of vehicle 703. This
transverse offset, designated as 712, with respect to
vehicle 703 can therefore be determined, although first
vehicle 700 has not yet reached the position of the first
detection of vehicle 703, which is designated as 708.a.

35   Therefore, from the point of view of first vehicle 700,
two transverse offsets 711 and 712 with respect to
vehicles traveling ahead 702 and 703 are known.

Furthermore, both course paths 709 and 710 of vehicles traveling ahead 702 and 703 are known. Using this known data, a future course path of first vehicle 700 on the basis of the two vehicles traveling ahead can now be determined. For this purpose, appropriately taking into account transverse offsets 711 and 712, the average value of course paths 709 and 710 is formed. The result is a determined future course path of first vehicle 700, which is designated in Figure 7 as 713. This determined future course path 713, by analogy to the related art according to Figure 6, is enlarged by the vehicle width as well as by any expansions. Course path 713 of first vehicle 700, expanded in this manner, represents the desired future travel-path area of first vehicle 700.

Alternatively, in place of determining the transverse offset between first vehicle 700 and course paths 709 and 710 of vehicles traveling ahead 702 and 703, a curvature between the current course path of first vehicle 700 and determined course paths 709 and 710 of vehicles traveling ahead 702 and 703 can be determined. On the basis of these known curvatures with respect to the course paths of the vehicles traveling ahead, a determination of a future course path of first vehicle 700 is also possible.

The determination of the future course path of first vehicle 700 is all the more precise, the greater the number of vehicles traveling ahead detected and their course paths determined. In this case, a verified future course path of first vehicle 700 through comparison, correlation, or an average of the projected course paths of all vehicles traveling ahead can be determined. In this context, projected course paths of vehicles traveling ahead can be filtered out, which, e.g., turn or, as a result of rapid lane change between the individual traffic lanes, do not yield any reliable course path or one that is suitable for the determination

of the future travel-path area.

Analytically, the conversion of detected relative
positional data 707 and 708 of vehicles traveling ahead
702 and 703 is accomplished using statistical analyses
and/or using mathematical interpolation procedures. The
result of this method is the projected course paths of
the vehicles traveling ahead, which are stored in the
storage device of the distance sensor of first vehicle
700. Within the storage device, which is organized
preferably as a ring storage device, the stored projected
course paths of the vehicles traveling ahead, at selected
or freely selectable time points, are compared with the
current coordinate system of the first vehicle. As a
result of this conversion, the projected course paths of
vehicles traveling ahead, at every time point, exist in
the same coordinate system as the coordinate system of
first vehicle 700. In order to assume the most relevant
of the determined projected course paths of the vehicles
traveling ahead in determining the future course path of
first vehicle 700, the projected course paths of the
vehicles traveling ahead are evaluated using a
performance index, which contains statistical as well as
nonpredictable and predictable components. On the basis
of this performance index, in the case of values that lie
below a predetermined threshold value, it can be decided
whether a projected course path of a vehicle traveling
ahead is determined as being irrelevant and therefore is
deleted from the storage device, or whether, e.g., the
relevance of this projected course path is only
conditionally present, and the course path is not to be
considered for determining the future travel-path area of
the first vehicle. In the event that the storage device
of the distance sensor of first vehicle 700 is full and
detected relative positional data of further vehicles
traveling ahead are present, then, in accordance with a
further performance index, which in this case

19   **SUBSTITUTE SPECIFICATION**

nevertheless only relies on predictable components, the decision is made whether the newly detected course path of a vehicle traveling ahead is so relevant that a previously stored projected course path of a vehicle traveling ahead should be deleted, or whether the newly detected relative positional data should be discarded. Using this method, it can be assured that, at every time point, the most relevant of the projected course paths of the vehicles traveling ahead are present in the storage device.

In the event that, on the basis of particular conditions or circumstances, the determined future travel-path area of first vehicle 700 extends beyond the area of road 701, then the future travel-path area is limited on the basis of stationary objects. This can be, e.g., as shown in Figure 7, traffic signs 704, guide posts 705, or trees and/or bushes 706. Also possible is a limitation of the determined future travel-path area on the basis of the positions of detected oncoming vehicles.

If a further future travel-path area of first vehicle 700 is determined, then verification of the future travel-path area of first vehicle 700 is possible. This further future travel-path area of first vehicle 700 can be determined, for example, on the basis of a steering angle, a steering wheel angle, a yaw rate, a difference between wheel speeds, or a transverse acceleration of the first vehicle, or on the basis of stationary objects or oncoming vehicles. In this manner, the future course path, or the future travel-path area, of first vehicle 700 is verified using different methods which are fully independent of each other.

Abstract

A method and a device are described for determining a
future travel-path area of a first vehicle, which is
furnished with a distance sensor. In this context, using
the distance sensor at preestablished or selectable time
points, at least relative positions are determined of at
least one vehicle traveling ahead with respect to the
first vehicle. At least these determined relative
positions are stored in at least one storage device.
These relative positions, stored in the storage device,
constitute in each case a course path of the
corresponding vehicle traveling ahead. The future travel-
path area of the first vehicle is determined at least on
the basis of the course path of the vehicle traveling
ahead. The course path of the vehicle traveling ahead is
projected in the direction of the position of the first
vehicle.

[10191/1775]

METHOD AND DEVICE FOR DETERMINING A FUTURE TRAVEL-PATH AREA OF A VEHICLE

The present invention relates to a method as well as a
device for determining a future travel-path area of a
motor vehicle. It can be applied, for example, in the
adaptive speed or distance control of a vehicle, in an
5   adaptive headlight leveling adjustment, or simply in
detecting critical situations. The presupposition is that
the vehicle is furnished with at least one sensor, which
can detect, and at least determine the position of,
vehicles traveling ahead and stationary objects in the
10   forward field of the vehicle. Sensors of this type can be
configured, for example, as radar, laser, or video
sensors. The present invention is used advantageously in
connection with an adaptive speed or distance control
system of a vehicle, because a sensor of this type is
15   already present in this application.

Background Information

In past years, numerous publications have appeared, which
20   deal with an automatic control system for the speed of a
motor vehicle while taking into consideration the
distance with respect to vehicles traveling ahead.
Systems of this type are frequently termed Adaptive
Cruise Control (ACC) or, in German, adaptive or dynamic
25   speed regulators. One fundamental problem in systems of
this type, in view of contemporary traffic patterns, is
an automatic decision as to which of a plurality of
vehicles traveling ahead is relevant, or most relevant,
for the speed or distance control system. This decision
30   is particularly difficult in the event that the road on
which the controlled vehicle is moving is multi-lane and

curvy. In this case, a distance sensor, which is used
inter alia for detecting vehicles traveling ahead,
usually also detects vehicles that are located on
neighboring lanes and that therefore have only minor

5   relevance for a distance control system.

Therefore, in an ACC system, there exists a need to
determine a future course path, or a future travel-path
area, of the controlled vehicle, in order, once this area

10   is known, to determine the specifically most relevant
vehicles traveling ahead or, conversely, to determine the
obstacle that at an instantaneous time point is the most
dangerous. Both variables, as well as the course path and
the travel-path area, are fundamentally oriented on the

15   direction of the road, but in the optimal case they also
take into account, if appropriate, any lane changing or
turning behavior carried out by the controlled vehicle.
In this context, the concept "future travel-path area" is
distinguished in what follows from the concept "future

20   travel-path" in that the former contains the entire
spatial area in which the controlled vehicle will
probably move. This means that it also takes into account
in each case the width required by the motor vehicle.

25   Currently known solutions to the aforementioned
formulation of the problem are described, for example, in
the publication "Adaptive Cruise Control -- System
Aspects and Development Trends" by Winner, Witte, et al,
published as SAE Technical Papers Series No. 961010 at

30   the SAE of February 26-29, 1996. In that publication, the
simplest way to predict a future course of a controlled
vehicle is to assume movement in a straight line.
However, it is obvious that this type of prediction does
not function in the case of curves or lane changes. A

35   more complex case, which nevertheless delivers sufficient
results for wide areas, is to assume a course having a
constant curvature. The latter is determined, for

example, on the basis of a difference of wheel speeds, a steering or steering wheel angle, transverse accelerations, and/or yaw rates. Corresponding methods are known from the field of driving dynamic control systems. One disadvantage in this method is that the future course path or travel-path area is only estimated, in each case on the basis of the present course. Therefore, here too, errors arise in response to every change of course, for example, in driving into or out of curves. A further possibility for predicting a course path, which is also mentioned in the cited publications, is the application of navigation systems. However, the limits of this method depend on how up-to-date and precise the available maps are and on the capacity of the system to determine, in each case, the current position of the vehicle. The prediction is particularly unreliable in construction zones or on new roads. As a further possibility, mention is made in the cited publication of a prediction of the road course or the lane based on radar data. Stationary objects are used such as reflectors or crash barriers, which are detected by a signal processor, in order to reconstruct the road borders. However, according to the publication, little is known regarding the quality and reliability of this method.

In U.S. Patent 4,786,164, a system and a method are described for detecting the distance between two vehicles which are moving in the same traffic lane. In this context, the lane in which each of the two vehicles is moving is determined on the basis of a comparison of angles at which reflectors that are placed on both sides of the road are detected. However, the method described here can only be used if suitable reflectors are actually present on both sides of the road, and is therefore dependent on infrastructure conditions.

In German Patent 196 14 061 A1, a system is described for controlling the distance to a vehicle traveling ahead on the basis of an adjustable probability distribution. This described system has a curvature determination device, in which the curvature of a road is determined on the basis of a steering angle and a vehicle speed. To improve the reliability, according to a first modification, the steering angle is determined on the basis of the motion of a specified stationary object. For this purpose, the locations of a stationary object relative to a system vehicle in motion are monitored at uniform time intervals. The locations are then defined as a circular arc to calculate the curvature of the road on which the system vehicle is traveling. According to a second modification, a sharp curve of the road can also be detected on the basis of a stationary object. According to a fourth modification, the calculated curvature can be increased or reduced if a turning signal indicates the right or left direction. According to a tenth modification, it is possible, on the basis of a navigation system, for example, a GPS system, to determine whether a curve is present in a forward direction of the system vehicle. However, not one of the methods presented in this document removes the disadvantages already cited in detail.

From German Patent 41 33 882 A1, a method is known for independently following a vehicle in the lane of a quite specific vehicle traveling ahead. For this purpose, using an electronic camera, the significant rear area of a leading vehicle is monitored and the sideways misalignment with respect to it is approximately determined. The goal is to obtain control signals for steering the vehicle carrying the camera.

From German Patent 43 41 689 A1, a system is known for detecting a vehicle traveling ahead. The point of

departure is a center line, which represents the
extension of the vehicle axis. Around this line, areas of
varying probabilities are defined, which are used to
recognize a detected target as being located in the lane

5   or as being irrelevant. The curvature of the road ahead
is calculated on the basis of the current steering angle
and of the current speed. A displacement is determined as
a function of this predicted curvature, at the distance
at which another vehicle has been detected, and the

10   previously determined probability distribution is shifted
by this value.

From the as yet not pre-published German patent
application 197 22 947.6-32, a method and a device are

15   known for determining a future travel-path area of a
vehicle. There, on the basis of the detected positions of
the vehicles traveling ahead, the course paths of the
latter are observed and in each case the transverse
offset is determined with respect to the first vehicle's

20   own position. This occurs in each case at the time point
at which the first vehicle has passed the point at which
a first position of the corresponding vehicle traveling
ahead had been stored in memory. Based on the knowledge
of this transverse offset and of the stored course paths

25   of the vehicles traveling ahead, a future travel-path
area of the first vehicle can be determined.

The disadvantage of the previous approaches to
determining the future travel-path area of a first

30   vehicle can be seen in the fact that the earliest
possible time point for determining a travel-path area is
the time point at which a point is passed at which a
position of a vehicle traveling ahead has been detected.

35   Objective, Solution, and Advantages of the Invention

The objective of the present invention, accordingly, is

to indicate a method and a device, based thereon, using which a future travel-path area of a first vehicle can be reliably determined. This travel-path area should be able to be determined reliably and in a timely fashion, especially when vehicles traveling ahead have been detected for the first time.

According to the present invention, this objective is achieved as a result of the fact that the future travel-path area of the first vehicle is determined at least on the basis of a course path of a vehicle traveling ahead that is projected onto the position of the first vehicle. This means that the detected course path of the vehicle traveling ahead is projected into an area in front of the first vehicle, in which no measured positions of the vehicle traveling ahead are present.

The advantage of the method according to the present invention and of the device according to the present invention can be seen in the fact that it is already possible to determine the future travel-path area of the first vehicle before a position is reached at which a vehicle traveling ahead has been detected. As a result of this invention, it is possible, in accordance with the speed of the first vehicle and the range of the distance sensor, to gain up to two seconds in comparison with previous methods and devices, in which it is already possible to determine the future travel-path area of the first vehicle. This can contribute to reducing the pressure on the driver of the first vehicle and to increasing general driving safety.

The course path of the vehicle traveling ahead can advantageously be projected up until the position at which the first vehicle is located. This allows the system the maximum exploitation of the stored data for determining the future travel-path area of the first

vehicle.

According to one preferred embodiment of the present invention, for this purpose, a transverse offset and/or a curvature is determined between the projected course path of the vehicle traveling ahead and the current course path of the first vehicle. Using the transverse offset and/or the curvature of the course path of the first vehicle with respect to the projected course path of the vehicle traveling ahead, a future travel-path area of the first vehicle is determined. This embodiment offers the advantage that, for determining the future travel-path area of the first vehicle, it is also possible to use a projected course path of a vehicle traveling ahead which is not moving in the same traffic lane as the first vehicle.

According to one advantageous refinement of the present invention, the future travel-path area is determined on the basis of the projected course paths of a plurality of vehicles traveling ahead. In this context, a lane change of a single vehicle traveling ahead is filtered out using comparison, correlation, or an average of the projected course paths of all vehicles traveling ahead. This refinement, especially given the presence of many other traffic participants, leads to improved reliability of the method according to the present invention and of the device according to the present invention. Therefore, all projected course paths of vehicles traveling ahead can be used for determining the travel-path area of the first vehicle, which results in improving the reliability of the determined travel-path area.

Furthermore, it is advantageous, at selected and/or freely selectable time points, to compare the stored course paths of the vehicles traveling ahead with the current coordinate system of the first vehicle. This has

the advantage that the storage device can be exploited very well for recording the projected course paths of vehicles traveling ahead, because a detected position of a vehicle traveling ahead, calculated with respect to the current coordinate system of the first vehicle, therefore represents a position relative to the first vehicle, and the data to be stored can be composed of, for example, only one distance and angle specification.

The course path of the vehicle traveling ahead is advantageously projected using statistical analyses and/or mathematical interpolation methods on the stored relative positional data. This analytic approach, and this interpolation method, make possible a very precise determination of the course path to be projected.

It is particularly advantageous to evaluate the projected course paths of the vehicles traveling ahead using at least one performance index, which contains both statistical as well as non-predictable and predictable components. Therefore, it is advantageously possible to delete from the storage device a projected course path of a vehicle traveling ahead having a performance index that lies beneath a predetermined threshold value, and/or not to consider it for determining the future travel-path area of the first vehicle. In this manner, on the one hand, exploitation of the storage device is improved because data which are less well-suited for determining the future travel-path area of the first vehicle are deleted from the storage device. On the other hand, it is therefore possible not to use less suitable data in determining the travel-path area, which leads to a more precise determination.

According to one refinement, the storage device is organized as a ring storage device. This refinement has the advantage that memory management is simplified, and

therefore determining the future course path of the first vehicle is accelerated. Especially in this type of storage organization, no shifting of data within the storage device is necessary. In plain language, the oldest stored data value for a course path of a vehicle traveling ahead is replaced by the currently detected value, and only a corresponding reference to the storage location is changed.

It is furthermore advantageous that when the storage device is full, for storing at least one new course path of a further vehicle traveling ahead, in accordance with a further performance index which rests only on predictable components, the decision is made as to whether at least one of the previously stored course paths and/or the at least one new course path should be deleted. This means that when the storage device is full, it is determined, using a performance index, whether a previously stored course path should be deleted, or whether the newly detected data have a worse index than all of the course paths stored in the storage device, and that therefore the newly stored data should be discarded.

According to one advantageous refinement of the present invention, the future travel-path area is limited on the basis of the positions of detected, stationary objects or on the basis of positions of detected, oncoming vehicles. This refinement has the advantage that it is possible to sensibly limit the determination of the future travel-path area of the first vehicle, which significantly increases the precision of the determined travel-path area. Furthermore, in this manner, further independent data contribute to determining the future travel-path area.

According to one particularly preferred embodiment of the present invention, in addition to the first future

travel-path area, determined in accordance with present
invention, at least one further future travel-path area
is determined on the basis of a steering angle, a
steering wheel angle, a yaw rate, a difference of wheel
speeds, or a transverse acceleration of the controlled
vehicle, or on the basis of stationary objects or of
oncoming vehicles which are detected by the distance
sensor of the first vehicle. On the basis of the first
and the at least one further determined future travel-
path area, a verified future travel-path area is then
determined. In plain language, this means that a future
travel-path area of the controlled vehicle is determined
on the basis of different methods that are independent of
each other. By combining these individually determined
future travel-path areas, errors individually arising in
the methods can be corrected, so that the verified future
travel-path area contains an optimal prediction of the
actual travel-path area.

One particular advantage of the method according to the
present invention and of the device according to the
present invention is that the future travel-path area is
determined on the basis of measuring data which actually
lie in the forward field of the controlled vehicle, and
that these data are projected in the direction of the
first vehicle's own position. In place of an estimation
based on extrapolating an instantaneous situation, the
situation actually existing in the forward field of the
vehicle is evaluated. In this manner, it is especially
possible to detect in a timely fashion the beginning or
end of a curve. As a result, the error rate is
significantly reduced compared with previously known
methods. A further advantage is that the method is
independent of particular infrastructure conditions, such
as specially provided reflectors on the road edge.
However, if appropriate reflectors are present, they can
be taken into account accordingly. Furthermore, the

method can be realized without special expense in a
vehicle which is equipped with an adaptive speed
regulating system, in particular without requiring an
additional image pick-up and image valuation unit.

5

In plain language, the movement of one or a plurality of
vehicles traveling ahead is observed for determining the
future course path or travel-path area of the first
vehicle. In this context, as long as a detected position

10   of a vehicle traveling ahead is not reached by the first
vehicle, the detected course path of the vehicle
traveling ahead is projected in the direction of the
first vehicle's own position. Therefore, determining the
travel-path area for the first vehicle is possible even

15   before a position has been reached at which a vehicle
traveling ahead has been detected.

Description of Exemplary Embodiments

20   Below, exemplary embodiments of the present invention are
discussed on the basis of a drawing. The following are
the contents.

Figure 1   depicts a basic representation of a device
25   according to the present invention,

Figure 2   and Figure 3
            depict two block diagrams, as an explanation of
            the method according to the present invention,

30
Figure 4   depicts a flowchart according to the
            aforementioned related art,

Figure 5   depicts a further flowchart according to the
35   aforementioned related art,

Figure 6   depicts a further flowchart according to the

aforementioned related art, for a detailed
explanation of the method, and

Figure 7   depicts a block diagram, as an explanation of
5   the method according to the present invention.

Figure 1 depicts a device for carrying out the method
according to the present invention. A distance sensor 10,
for example, a radar or a laser sensor, is connected to
10   an evaluation and control unit 11. Evaluation and control
unit 11 receives numerous further signals, of which, by
way of example, an input 13 for the vehicle's own speed,
an input 14 for a steering angle, and an input 15 for a
yaw rate are depicted here. Furthermore, evaluation and
15   control unit 11 is connected to one or a plurality of
actuators 12. The entire device is installed in a first
vehicle. Using distance sensor 10, in accordance with the
known methods, vehicles traveling ahead, oncoming
vehicles, as well as stationary objects on, and on both
20   sides of, the roadway are detected. Corresponding
measuring data are pre-processed and are supplied to
evaluation and control unit 11. The latter, in accordance
with the method described below, determines at least one
future travel-path area of the first vehicle. In the
25   context of an adaptive speed regulation, evaluation and
control unit 11, via actuator or actuators 12, controls
or regulates the speed of the vehicle. Alternatively, or
as a supplement, the unit, via actuators 12, controls,
for example, the headlight range or the light cone of the
30   headlights of the vehicle, or it generates a warning
signal for a critical situation.

Figure 2 depicts a two-lane road 20, on which two
vehicles 21 and 22 are moving in the same direction.
35   Reference numeral 21 designates the vehicle which has the
device according to the present invention. Extending from
the front of vehicle 21, an angular area 24 is sketched,

which symbolizes the detection range of distance sensor 10. A dot-dash line 26 depicts the future course path of vehicle 21. Two solid lines 27 designate the future travel-path area of vehicle 21. This future travel-path area results from future course path 26 of vehicle 21, enlarged by the vehicle width and any additional expansions. A distance 23 indicates a lateral transverse offset q between vehicles 21 and 22. Reference numeral 25 designates a stationary object, for example, a tree at the road edge.

Figure 3 also depicts a two-lane road 30, on which three vehicles 31, 32, and 33 are represented at two different time points t_0 and t_1. The positions of the vehicles at time point t_0 are represented in dotted lines and are designated as 31a, 32a, and 33a. The positions of the vehicles at time point t_1 are designated as 31b, 32b, and 33b. Two distances 34 and 35 designate in each case a transverse offset q_1 and q_2 between vehicles 31 and 32 and between vehicles 31 and 33 respectively.

Figure 4 depicts a flowchart in accordance with the aforementioned related art. In step 41, using distance sensor 10, vehicles traveling ahead F_{vi} are detected. In this context, according to Figure 2 and Figure 3, vehicles 22 as well as 32 and 33 are detected. In step 42, a position P_{vi} of each individual vehicle traveling ahead is determined. Depending on the specific configuration, this step can be carried out either by an evaluation circuit within distance sensor 10 or by evaluation and control unit 11. Determined positions P_{vi} of vehicles traveling ahead F_{vi} contain a distance d_i and an angle α_i. In step 43, a transverse offset q_i is determined, which in Figures 2 and 3 is indicated by the distances 23, 34, and 35. In purely mathematical terms, transverse offset q_i yields

$$q_i = d_i * \sin\alpha_i.$$

However, because the curvature of road 20_r and 30_r and an additional transverse offset of vehicles F_{vi}, resulting therefrom, are not taken into account in this connection, specific transverse offset q_i is determined on the basis of position P of vehicle 31 at time point t_1 and of position P_{vi} of vehicles traveling ahead 32, 33 at time point t_0. In other words, transverse offset q_i in this context is only determined if first vehicle 31 is located at or near the position which the specific vehicle traveling ahead occupied at one or more measuring time points previously.

In step 44, future travel-path area KB of controlled vehicle 21, 31 is determined on the basis of an assumed width b of the first vehicle, on the basis of course path KV_i of vehicles traveling ahead F_{vi}, on the basis of the latter's specific transverse offset q_i, and, if appropriate, on the basis of previously determined course paths. In this context, the assumption is made that the first vehicle will continue to move as the vehicle traveling ahead or vehicles. When an intended or commencing lane change of the first vehicle is detected, for example, as a function of a blinker signal, the determined probable travel-path area is expanded in the corresponding direction. This distinguishes determined future travel-path area KB from a pure prediction of the road course. In step 47, the determination of future travel-path area KB of the first vehicle is carried out in an iterative manner, i.e., it is followed by a new determination cycle. In step 45, the determined future travel-path area is limited on the basis of stationary objects 25, and, if present, on the basis of detected oncoming vehicles F_G, which are not shown in Figures 2 and 3.

Subsequent step 46 relates to the application in the context of an adaptive speed and distance control system. Here, a vehicle traveling ahead is selected as the control target for the distance control system. In this context, only those vehicles traveling ahead are taken into account which are located within determined future travel-path area KB. If a plurality of vehicles traveling ahead are located in this area, then a selection is carried out concerning which of the vehicles traveling ahead requires the smallest desired acceleration, or the greatest desired deceleration, in the controlled vehicle. However, the selection, alternatively or as a supplement, can also be made as a function of other criteria. For example, the selection can be carried out in accordance with which of the vehicles traveling ahead has the least distance from the first, controlled vehicle. Reference numeral 48 designates the iterative repetition of the method.

Figure 5 depicts a further flowchart in accordance with the above-mentioned related art. Steps 51 through 54, in this context, correspond to steps 41 through 44 according to the related art in Figure 4. According to this second example from the related art, in step 55, a determination is made of the verified, future travel-path area KBver. For this purpose, in step 56, further measuring data are used, especially future travel-path area KB_2, determined elsewhere. This future travel-path area KB_2, which is determined elsewhere, can be determined, for example, on the basis of the methods known in the related art, using a yaw rate or a transverse acceleration. By linking a plurality of determined future travel-path areas that are independent of each other, the error rate present in a given system is further minimized. In the simplest case, linking two determined future travel-path areas KB and KB_2 is carried out as a result of the fact that first determined travel-path area KB is used as long as an

preestablished minimum number of vehicles traveling ahead
is detected. If fewer vehicles traveling ahead are
detected than this preestablished number, then future
travel-path area KB_2 is used. Alternatively, the data of

5   both determined travel-path areas KB and KB_2 can also be
correlated with each other, to obtain verified travel-
path area KBver. In step 58, determining a future
verified travel-path area also takes place in an
iterative manner. Step 57 corresponds to step 46 from

10 Figure 4 and also contains a target selection of one
vehicle traveling ahead in the context of an adaptive
speed and distance regulation.

Figure 6 depicts a further flowchart according to the

15 above-mentioned related art for a more detailed
representation of the method steps for determining future
travel-path area KB in steps 44 and 54 of Figures 4 and
5. Accordingly, steps 61 through 63 can be inserted in
place of steps 44 and 54 in Figures 4 and 5. In step 61,

20 points of reference S_i are determined, in that positions
P_{vi} of detected vehicles traveling ahead F_{vi} are set off
against the relevant determined transverse offsets q_i. In
the ideal case, all determined points of reference S_i will
lie on one curve, which corresponds to future course path

25 KV of the first vehicle. In step 62, this course path KV
is determined, in that a function is determined, for
example, in the form of a polynomial, which at least
approximately, to the extent possible, covers all points
of reference S_i. This determined function then describes

30 future course path KV. In step 63, future travel-path
area KB is determined, in that course path KV is expanded
by width b of the first vehicle. Additionally, if
necessary, a further expansion E takes place as a
function of the detected lane-change signals of the first

35 vehicle.

Figure 7 depicts a schematic diagram, as an explanation

of the method according to the present invention. In this context, reference numeral 700 designates the first vehicle, which is traveling on a multilane road 701. In the further course of road 701, two vehicles traveling ahead 702 and 703 are depicted. At the edge of road 701 are also located traffic signs 704, directional posts 705, and trees, which are designated as 706. It is clear that first vehicle 700 is moving on the center lane of three-lane road 701. Vehicle traveling ahead 702 is moving on the right-hand lane relative to vehicle 700, whereas vehicle traveling ahead 703 is moving on the left-hand lane relative to first vehicle 700. First vehicle 700 is equipped with a distance sensor, which detects the positions of vehicles traveling ahead. The detected positions of vehicle traveling ahead 702 are depicted as crosses and are designated as 707. The detected positions of vehicle traveling ahead 703 are also depicted as crosses and are designated as 708. In the case of vehicle traveling ahead 702, it is clear that the positions of vehicle 702 have already been detected by first vehicle 700, the positions being located at least at the same level as first vehicle 700 or even on the path already traveled. Using positions 707, detected in this manner and stored in a storage unit, it is possible to determine a comparison curve, which represents course path 709 of vehicle traveling ahead 702. Based on the course path of vehicle traveling ahead 702 and of the known position of first vehicle 700, it is easy to determine transverse offset 711 between first vehicle 700 and course path 709 of vehicle traveling ahead 702. Assuming that vehicle traveling ahead 702 is the only vehicle traveling ahead, it would be possible to determine the future course path of first vehicle 700 on the basis of known course path 709 of vehicle traveling ahead 702 and of known transverse offset 711. This future course path of first vehicle 700, if only one reference vehicle 702 is forward, would move by transverse offset

711, shifted parallel to course path 709.

In the case of vehicle traveling ahead 703, no detected
positions 708 are yet present, which are located at least
at the same level as first vehicle 700. The first
detected position of vehicle 703 is designated as 708.a
and is situated still in front of the current position of
first vehicle 700. On the basis of detected positions 708
of vehicle 703, by analogy to the procedure for vehicle
702, an offset line 710 can be determined, which
represents the course path of vehicle traveling ahead
703. If course path 710 of vehicle 703 is projected, or
interpolated, in the direction of first vehicle 700, the
result is an extension of course path 710 by path 710.a,
which extends up to the current position of first vehicle
700. Based on this projected course path 710.a of vehicle
703, it is possible to determine a transverse offset
between the current position of first vehicle 700 and
projected course path 710.a of vehicle 703. This
transverse offset, designated as 712, with respect to
vehicle 703 can therefore be determined, although first
vehicle 700 has not yet reached the position of the first
detection of vehicle 703, which is designated as 708.a.
Therefore, from the point of view of first vehicle 700,
two transverse offsets 711 and 712 with respect to
vehicles traveling ahead 702 and 703 are known.
Furthermore, both course paths 709 and 710 of vehicles
traveling ahead 702 and 703 are known. Using this known
data, it is now possible to determine a future course
path of first vehicle 700 on the basis of the two
vehicles traveling ahead. For this purpose, appropriately
taking into account transverse offsets 711 and 712, the
average value of course paths 709 and 710 is formed. The
result is a determined future course path of first
vehicle 700, which is designated in Figure 7 as 713. This
determined future course path 713, by analogy to the
related art according to Figure 6, is enlarged by the

vehicle width as well as by any expansions. Course path 713 of first vehicle 700, expanded in this manner, represents the desired future travel-path area of first vehicle 700. For reasons of simplicity, this determined

5   future travel-path area is not depicted in Figure 7.

Alternatively, in place of determining the transverse offset between first vehicle 700 and course paths 709 and 710 of vehicles traveling ahead 702 and 703, a curvature

10   between the current course path of first vehicle 700 and determined course paths 709 and 710 of vehicles traveling ahead 702 and 703 can be determined. On the basis of these known curvatures with respect to the course paths of the vehicles traveling ahead, a determination of a

15   future course path of first vehicle 700 is also possible.

The determination of the future course path of first vehicle 700 is all the more precise, the greater the number of vehicles traveling ahead detected and their

20   course paths determined. In this case, the possibility exists to determine a verified future course path of first vehicle 700 through comparison, correlation, or an average of the projected course paths of all vehicles traveling ahead. In this context, projected course paths

25   of vehicles traveling ahead can be filtered out, which, e.g., turn or, as a result of rapid lane change between the individual traffic lanes, do not yield any reliable course path or one that is suitable for the determination of the future travel-path area.

30

Analytically, the conversion of detected relative positional data 707 and 708 of vehicles traveling ahead 702 and 703 is accomplished using statistical analyses and/or using mathematical interpolation procedures. The

35   result of this method is the projected course paths of the vehicles traveling ahead, which are stored in the storage device of the distance sensor of first vehicle

700. Within the storage device, which is organized preferably as a ring storage device, the stored projected course paths of the vehicles traveling ahead, at selected or freely selectable time points, are compared with the current coordinate system of the first vehicle. As a result of this conversion, the projected course paths of vehicles traveling ahead, at every time point, exist in the same coordinate system as the coordinate system of first vehicle 700. In order to assume the most relevant of the determined projected course paths of the vehicles traveling ahead in determining the future course path of first vehicle 700, the projected course paths of the vehicles traveling ahead are evaluated using a performance index, which contains statistical as well as nonpredictable and predictable components. On the basis of this performance index, in the case of values that lie below a predetermined threshold value, it can be decided whether a projected course path of a vehicle traveling ahead is determined as being irrelevant and therefore is deleted from the storage device, or whether, e.g., the relevance of this projected course path is only conditionally present, and the course path is not to be considered for determining the future travel-path area of the first vehicle. In the event that the storage device of the distance sensor of first vehicle 700 is full and detected relative positional data of further vehicles traveling ahead are present, then, in accordance with a further performance index, which in this case nevertheless only relies on predictable components, the decision is made whether the newly detected course path of a vehicle traveling ahead is so relevant that a previously stored projected course path of a vehicle traveling ahead should be deleted, or whether the newly detected relative positional data should be discarded. Using this method, it is assured that, at every time point, the most relevant of the projected course paths of the vehicles traveling ahead are present in the storage

device.

In the event that, on the basis of particular conditions
or circumstances, the determined future travel-path area
of first vehicle 700 extends beyond the area of road 701,
then the future travel-path area is limited on the basis
of stationary objects. This can be, e.g., as depicted in
Figure 7, traffic signs 704, guide posts 705, or trees
and/or bushes 706. Also possible is a limitation of the
determined future travel-path area on the basis of the
positions of detected oncoming vehicles. This latter
possibility is not depicted in Figure 7.

If a further future travel-path area of first vehicle 700
is determined, then verification of the future travel-
path area of first vehicle 700 is possible. This further
future travel-path area of first vehicle 700 can be
determined, for example, on the basis of a steering
angle, a steering wheel angle, a yaw rate, a difference
between wheel speeds, or a transverse acceleration of the
first vehicle, or on the basis of stationary objects or
oncoming vehicles. In this manner, the future course
path, or the future travel-path area, of first vehicle
700 is verified using different methods which are fully
independent of each other. This makes possible the best
possible determination of the future travel-path area of
first vehicle 700.

Patent Claims

1. A method for determining a future travel-path area of a first vehicle (700), which is equipped with a distance sensor,
- at least the relative positions (707, 708) of at least one vehicle traveling ahead (702, 703) being determined with respect to the first vehicle (700), using the distance sensor at preestablished or selectable time points,
- at least these determined, relative positions (707, 708) being stored in at least one storage device,
- these relative positions (707, 708), stored in the storage device, constituting in each case a course path (709, 710) of the corresponding vehicles traveling ahead (702, 703), and
- the future travel-path area of the first vehicle (700) being determined at least on the basis of the course path (709, 710) of the vehicle traveling ahead (702, 703), wherein
- the course path (709, 710) of the vehicle traveling ahead (702, 703) is projected in the direction of the position of the first vehicle (700).

2. The method as recited in Claim 1,
wherein the projection of the course path of the vehicle traveling ahead (702, 703) occurs up to the position in which the first vehicle is located.

3. The method as recited in Claim 1 or 2,
wherein between the projected course path (709, 710, 710.a) of the vehicle traveling ahead (702, 703) and the current course path of the first vehicle (700), a transverse offset (711, 712) and/or a curvature is determined.

4. The method as recited in Claim 3,

wherein a future travel-path area of the first vehicle
(700) is determined, using the transverse offset (711,
712) and/or the curvature of the course path of the first
vehicle (700) with respect to the projected course path
(709, 710, 710.a) of the vehicle traveling ahead (702,
703).

5. The method as recited in Claim 4,
wherein the future travel-path area is determined on the
basis of the projected course paths (709, 710, 710.a) of
a plurality of vehicles traveling ahead (702, 703), and
that a lane change of one single vehicle traveling ahead
(702, 703) is filtered out using comparison, correlation,
or an average of the projected course paths of all
vehicles traveling ahead (702, 703).

6. The method as recited in Claim 1,
wherein the stored course paths (709, 710, 710.a) of the
vehicles traveling ahead (702, 703), at selected and/or
freely selectable time points, are compared with the
current coordinate system of the first vehicle (700).

7. The method as recited in Claim 1,
wherein the projection of the course path (709, 710,
710.a) of the vehicle traveling ahead (702, 703) is
accomplished using statistical analyses and/or
mathematical interpolation procedures on the stored
relative positional data (707, 708).

8. The method as recited in Claim 1,
wherein the projected course paths (709, 710, 710.a) of
the vehicles traveling ahead (702, 703) are evaluated
using at least one performance criterion, which contains
both statistical as well as nonpredictable and
predictable components.

9. The method as recited in Claim 8,

wherein a projected course path (709, 710, 710.a) of a
vehicle traveling ahead (702, 703), which has a
performance criterion that is lower than a predetermined
threshold value,
- is deleted from the storage device and/or
- is not considered for determining the future travel-
path area of the first vehicle (700).

10. The method as recited in Claim 1,
wherein the storage device is organized as a ring storage
device.

11. The method as recited in Claim 1,
wherein, if the storage device is full, for storing at
least one new course path of a further vehicle traveling
ahead, in accordance with a further performance
criterion, which is based only on predictable components,
the decision is made whether at least one of the
previously stored course paths and/or at least one new
course path should be deleted.

12. The method as recited in Claim 1,
wherein the future travel-path area is limited on the
basis of the positions of detected, stationary objects
(704, 705, 706) or on the basis of the positions of
detected, oncoming vehicles.

13. The method as recited in Claim 1,
wherein
- at least one further future travel-path area of the
first vehicle (700) is determined on the basis of a
steering angle, a steering wheel angle, a yaw rate, a
difference of wheel speeds, or a transverse acceleration
of the first vehicle (700), or on the basis of stationary
objects or oncoming vehicles which are detected by the
distance sensor of the first vehicle (700) and
- a verified future travel-path area is determined on

basis of the first and second determined future travel-path area.

14. A device for carrying out the method as recited in Claim 1, comprising,
- a distance sensor, which at preestablished or selectable time points determines at least the relative positions (707, 708) of at least one vehicle traveling ahead (702, 703) with respect to the first vehicle (700),
- at least one storage device, in which these determined relative positions (707, 708) are stored,
- means, in each case, to formulate, from these relative positions (707, 708) stored in the storage device, a travel-path (709, 710) of the corresponding vehicle traveling ahead (702, 703), and
- means to determine the future travel-path area of the first vehicle (700), at least on the basis of the course path (709, 710) of the vehicle traveling ahead (702, 703),
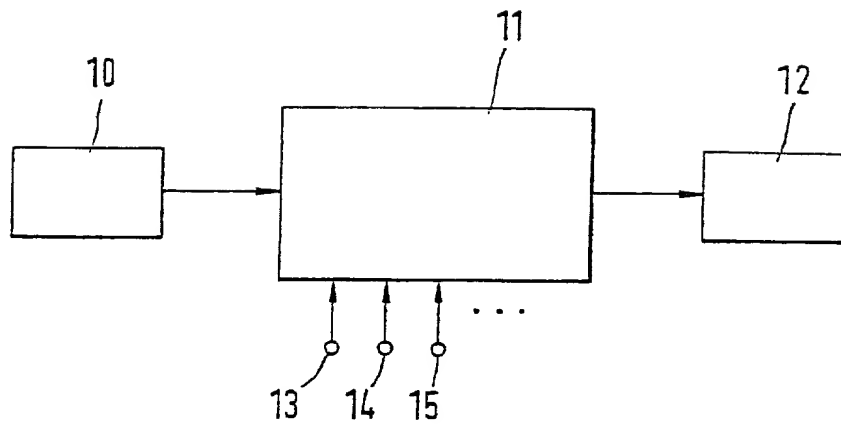wherein
- means are present to project the travel-path (709, 710) of the vehicle traveling ahead (702, 703), in the direction of the position of the first vehicle (700).

Abstract

A method and a device are described for determining a
future travel-path area of a first vehicle (700), which
is furnished with a distance sensor. In this context,
using the distance sensor at preestablished or selectable
time points, at least relative positions (707, 708) are
determined of at least one vehicle traveling ahead (702,
703) with respect to the first vehicle (700). At least
these determined relative positions (707, 708) are stored
in at least one storage device. These relative positions
(707, 708), stored in the storage device, constitute in
each case a course path (709, 710) of the corresponding
vehicle traveling ahead (702, 703). The future travel-
path area of the first vehicle (700) is determined at
least on the basis of the course path (709, 710) of the
vehicle traveling ahead (702, 703). The course path (709,
710) of the vehicle traveling ahead (702, 703) is
projected in the direction of the position of the first
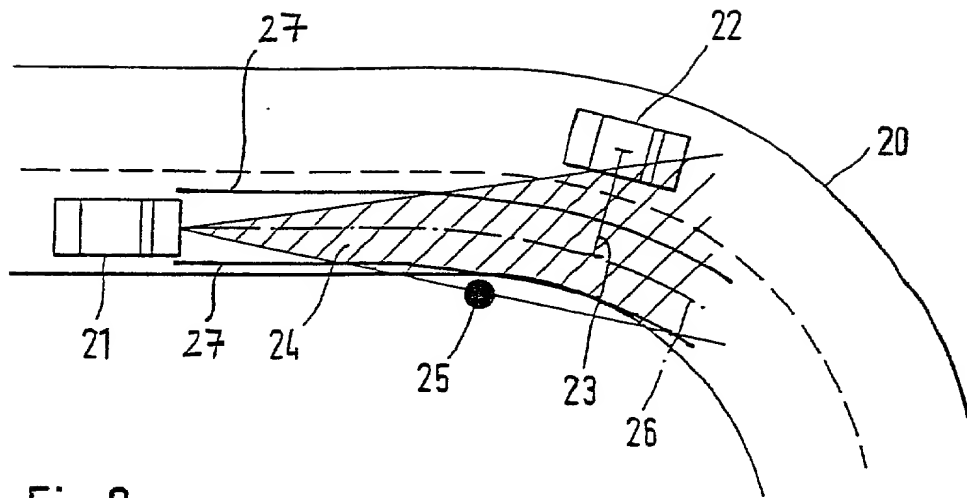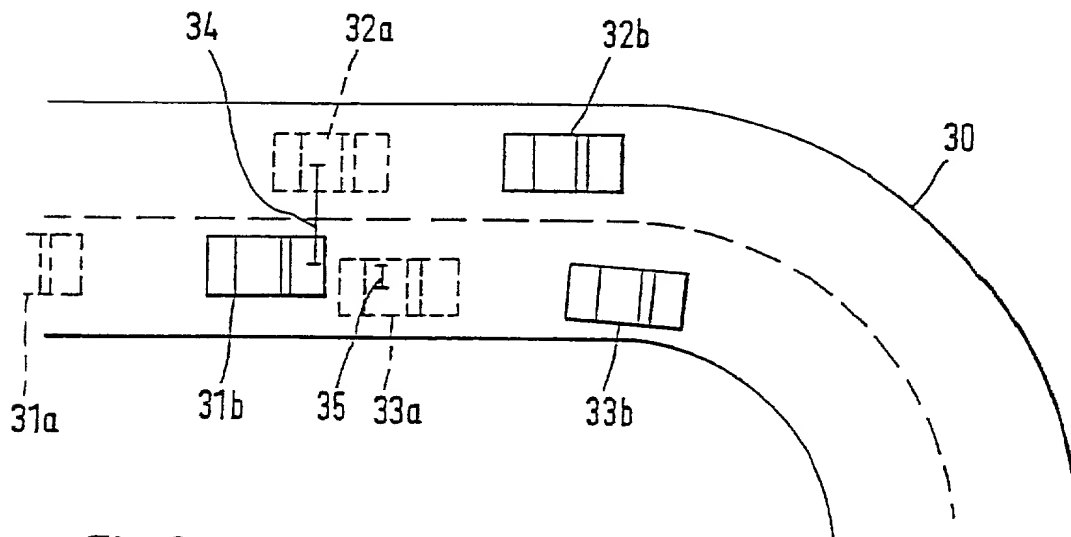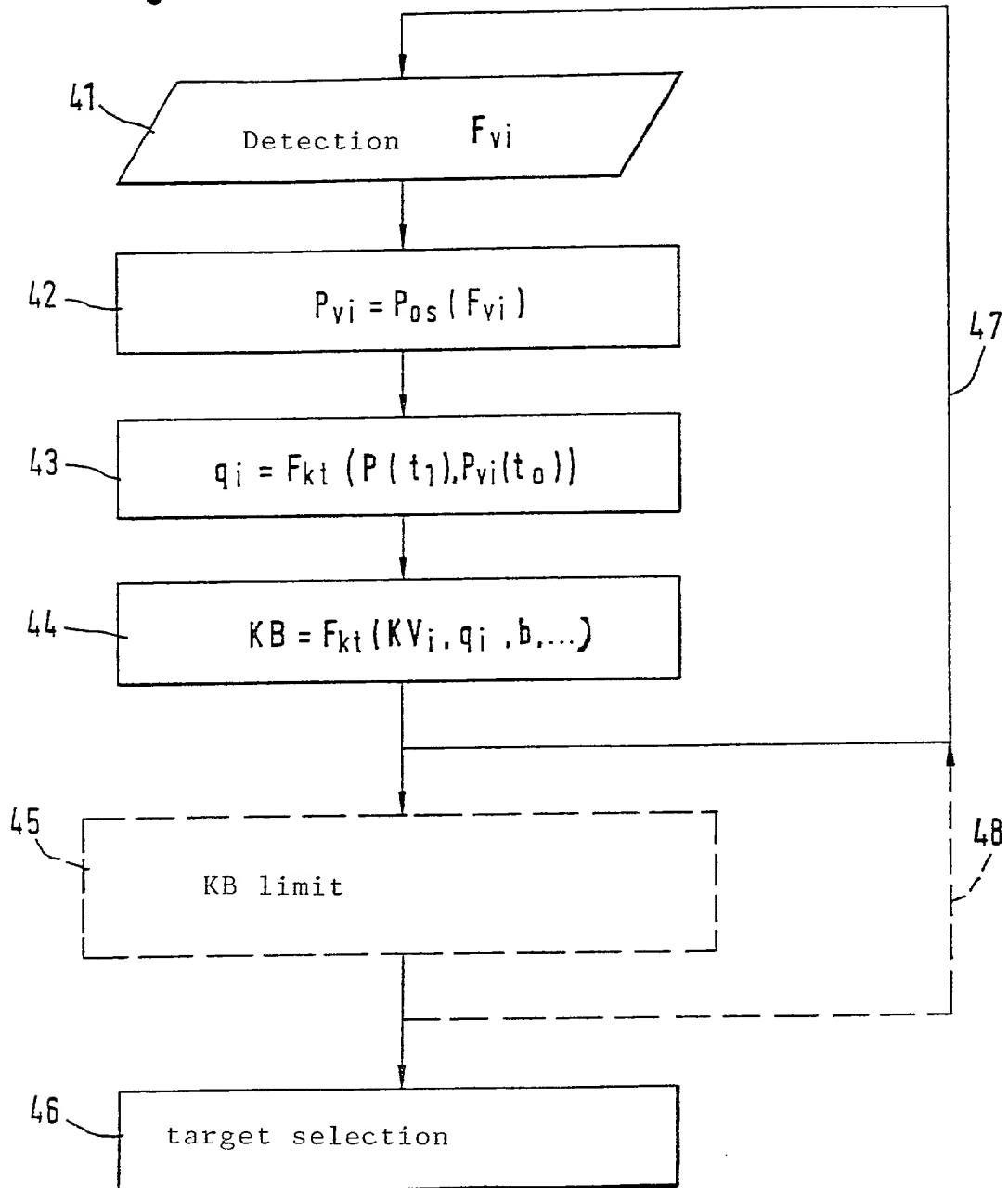vehicle (700).

(Figure 7)

Fig.1

Fig.2

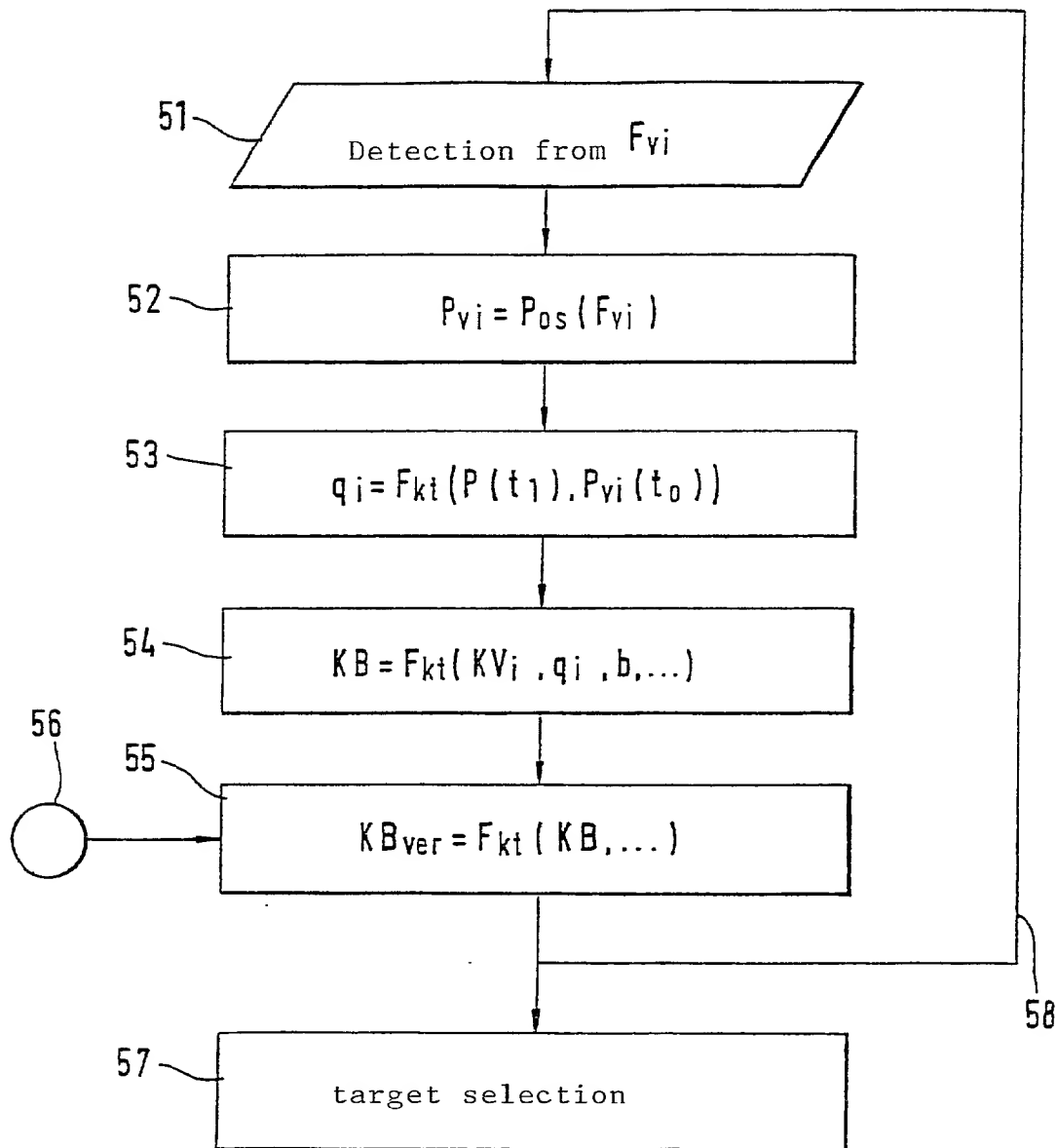Fig.3

RELATED ART

Fig.4

41 — Detection F_{vi}

42 — $P_{vi} = P_{os}(F_{vi})$

43 — $q_i = F_{kt}(P(t_1), P_{vi}(t_0))$

44 — $KB = F_{kt}(KV_i, q_i, b, ...)$

45 — KB limit

46 — target selection

47

48

09/857113

RELATED ART

Fig.5

51 — Detection from F_{vi}

52 — $P_{vi} = P_{os}(F_{vi})$

53 — $q_i = F_{kt}(P(t_1), P_{vi}(t_0))$

54 — $KB = F_{kt}(KV_i, q_i, b, \ldots)$

56

55 — $KB_{ver} = F_{kt}(KB, \ldots)$

58

57 — target selection

RELATED ART

Fig.6

```
Start
```

$$S_i = P_{vi} \pm q_i$$ ——61

$$KV = Fkt \ (S_i)$$ ——62

$$KB = KV \pm \frac{b}{2} + E$$ ——63

```
termination
```

Fig.7

703

713

702

705

706

708
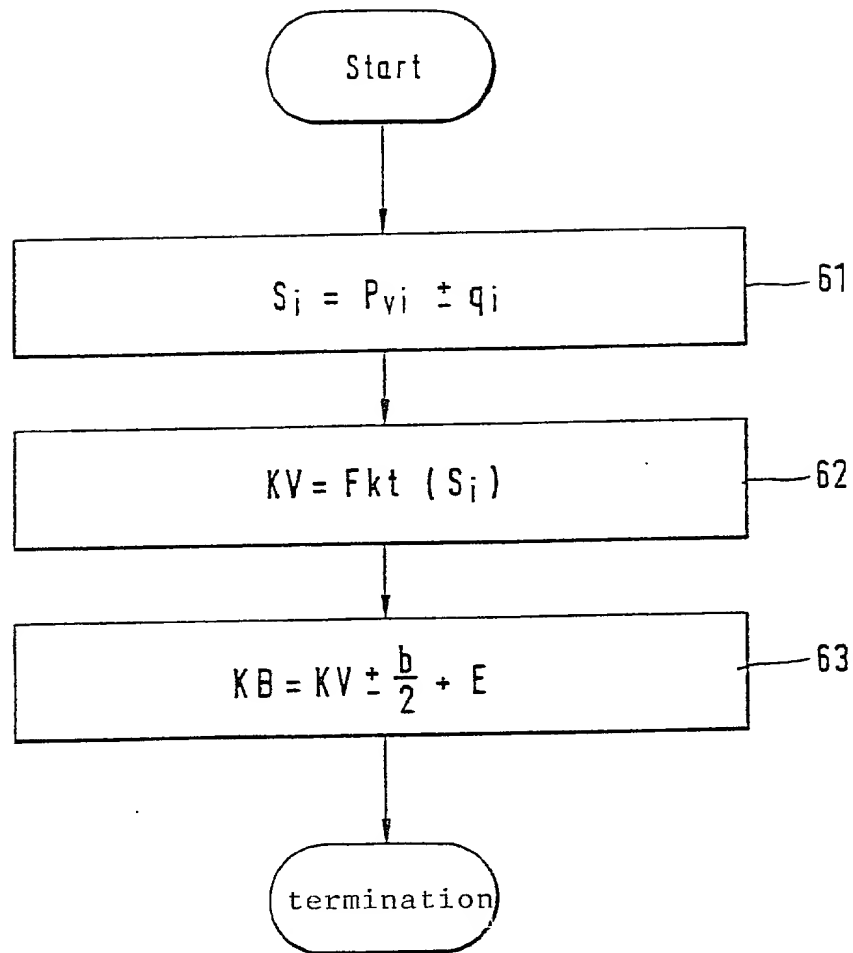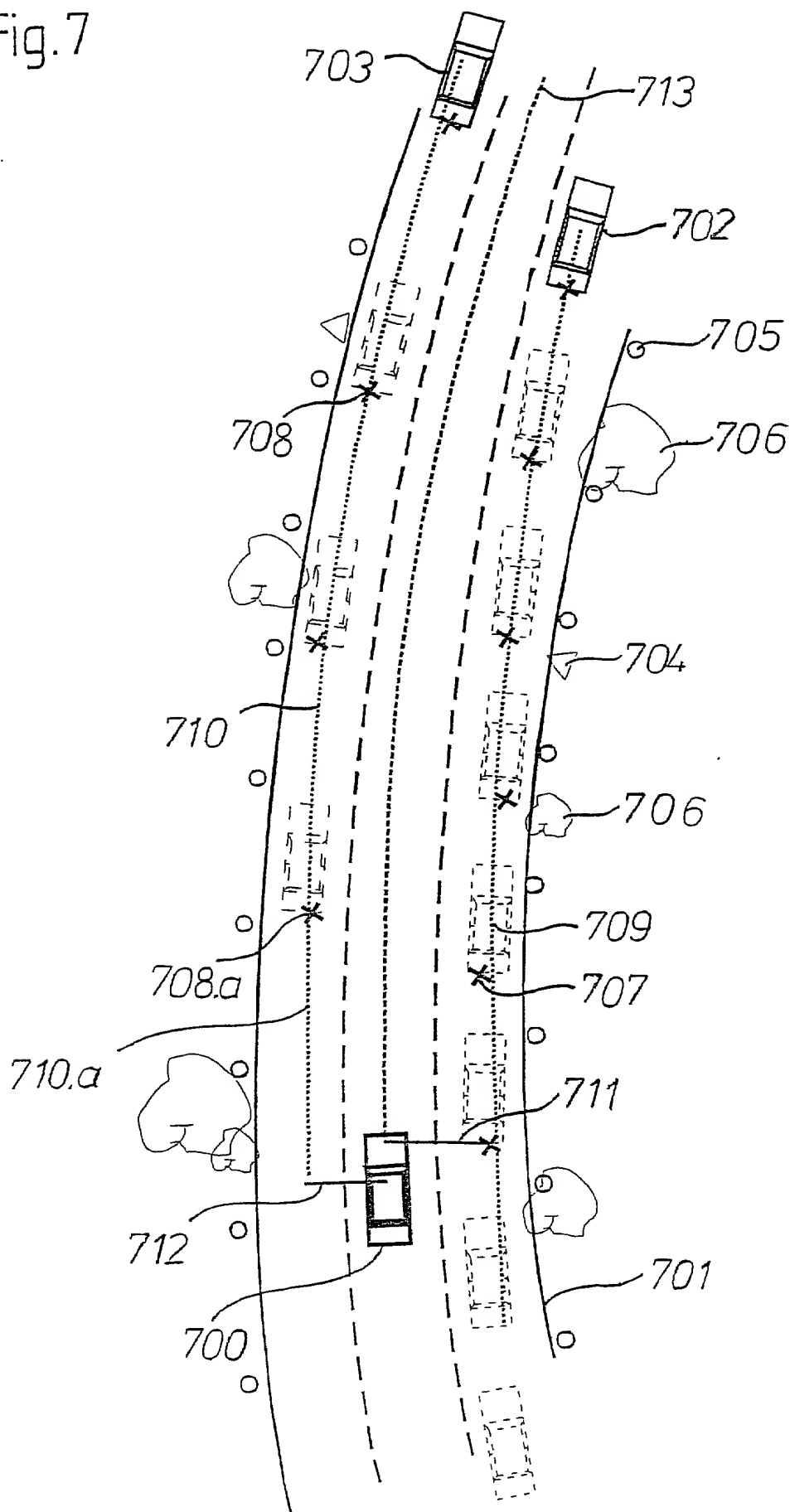
710

704

706

708.a

709

710.a

707

711

712

700

701

DECLARATION AND POWER OF ATTORNEY

As a below named inventor, hereby declare that:

My residence, post office address and citizenship are as stated below next to my name.

I believe I am the original, first and joint inventor of the subject matter which is claimed and for which a patent is sought on the invention entitled **METHOD AND DEVICE FOR DETERMINING A FUTURE TRAVEL-PATH AREA OF A VEHICLE** for which an application for Letters Patent was filed as PCT International Application No. **PCT/DE99/03219** on **October 6, 1999.**

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims.

I acknowledge the duty to disclose information which is material to the examination of this application in accordance with Title 37, Code of Federal Regulations, § 1.56(a).

I hereby claim foreign priority benefits under Title 35, United States Code, § 119 of any foreign application(s) for patent or inventor's certificate listed below and have also identified below any foreign application(s) for patent or inventor's certificate having a filing date before that of the application on which priority is claimed:

PRIOR FOREIGN APPLICATION(S)

Number	Country	Day/month/year filed	Priority Claimed Under 35 USC §119
198 55 400.1	Fed. Rep. of Germany	01 December 1998	YES

And I hereby appoint Richard L. Mayer (Reg. No. 22,490) and Gerard A. Messina (Reg. No. 35,952) my attorneys with full power of substitution and revocation, to prosecute this application and to transact all business in the Patent and Trademark Office connected therewith.

Please address all communications regarding this application to:

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PATENT TRADEMARK OFFICE

Please direct all telephone calls to Richard L. Mayer at (212) 425-7200.

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful and false statements may jeopardize the validity of the application or any patent issued thereon.

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